Interim Report on the Sonoran Pronghorn Antelope

(Antilocapra americana sonoriensis)

October 1983-March 1985

Arizona Game and Fish Department

August 1985

Interim Report on the Sonoran Pronghorn Antelope (*Antilocapra americana sonoriensis*) October 1983 - March 1985

Prepared for:

Office of Endangered Species
U.S. Fish and Wildlife Service
P.O. Box 1306
Albuquerque, NM 87103

Prepared by:

Arizona Game and Fish Department
Rebecca L. Wright, Wildlife Assistant
James C. deVos, Jr., Field Contracts Administrator
Special Services Division
2222 West Greenway Road
Phoenix, AZ 85023-4399

Contract No. 14-16-0002-82-216

August 1985

SCYProng

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ACKNOWLEDGEMENTS

Many people contributed in conducting this project and in writing this report. I especially would like to thank Robert B. Spicer for the time he spent discussing all aspects of this paper with me, and for the time he spent editing. I would also like to thank Lyle B. Williams of the Cabeza Prieta National Wildlife Refuge for the assistance he gave me in learning the study area, assisting in the fieldwork, and for spending many hours discussing Sonoran pronghorn. Richard Remington, Game Specialist, Region IV of the Arizona Game and Fish Department, has assisted throughout the project and his contribution is greatly appreciated.

Personnel of the U.S. Fish and Wildlife Service Endangered Species Office and Cabeza Prieta National Wildlife Refuge assisted in many ways; I thank Curtis Carley of E.S.O. and Linda Hagen, Josafina Mize and Dennis Sequaro of CPNWR. Harold Smith of Organ Pipe National Monument contributed data on pronghorn within the OPNM boundaries and in Mexico. Also, I thank personnel of Luke Air Force Base for arranging air space clearance every week for the telemetry flights.

Many thanks to Joanne Bedrin for typing the drafts and final copy.

STATUS SUMMARY

Taxon Name:	*Antilocapra americana sonoriensis* (Goldman)
Common Name:	Sonoran pronghorn antelope
Family:	Antilocapridae
Order:	Artiodactyla
Counties and States Where Located:	Yuma, Pima and Maricopa Counties, Arizona Sonora, Mexico
Current International Status:	Code of Federal Regulations, Title 50, Chapter 1 USFWS Subpart C § 23.23, Appendix 1, October 1, 1984, p235, listed 7-1-75.
Current Federal Status:	USFWS Endangered & Threatened Wildlife & Plants, July 27, 1983, page 8. 50CFR 17.11 & 17.12. Endangered, listed March 11, 1967.
Current State Status:	Threatened Native Wildlife in Arizona, Arizona Game and Fish Commission December 10, 1982, page 12. Group 3 (continued presence in Arizona could be in jeopardy in the foreseeable future).

I. INTRODUCTION

Pronghorn antelope (*Antilocapra americana*) are found only in North America, with five subspecies currently recognized: *Antilocapra americana americana*, *A. a. mexicana*, *A. a. oregona*, *A. a. peninsularis*, and *A. a. sonoriensis*. The latter subspecies is found in the Sonoran desert of southwestern Arizona and northern Sonora, Mexico. Due in part to its geographical isolation in one of the harshest environments in the U.S. and Mexico, little is known about the smallest of the North American pronghorn. A few notes and results of several census surveys have appeared in the literature over the last 60 years. Two studies were conducted by the Arizona Game and Fish Department, one in 1968 (as a result of Pittman-Robertson funding in 1967) and one in 1980. Both studies concluded that more extensive fieldwork was necessary for taxonomic clarification and to provide data for management of Sonoran pronghorn.

Four participants are funding this current study - the U.S. Fish and Wildlife Service (USFWS), Arizona Game and Fish Department (AGFD), Shikar Safari, and the U.S. Department of Defense (Air Force). Field data have been collected by AGFD employees and with assistance from personnel of the Cabeza Prieta National Wildlife Refuge (CPNWR) and Organ Pipe National Monument (OPNM). This report is an interim report covering the period from October 1983 to March 1985.

II. BACKGROUND

A. Classification

An adult doe pronghorn was collected by Vernon Bailey and Frederick Winthrop on December 11, 1932 from 64 km north of the Costa Rica ranch, on the north side of the Rio de Sonora, southwest of Hermosillo, Sonora, Mexico (Goldman 1945). It was placed in the U.S. Biological Surveys collection (original #11291). E.A. Goldman (1945) named and described the specimen as *Antilocapra americana sonoriensis*, a previously undescribed race of pronghorn from the desert region of central western Sonora. At the time, he also examined a specimen of a doe from Fort Buchanan (now Crittenden), Santa Cruz County, Arizona, and referred to it as *A. a. sonoriensis*. It is now felt this specimen is an intermediate between *sonoriensis* and *mexicana* reference, exhibiting cranial features of both subspecies (Paradiso and Nowak 1971). Until 1969, these were the only specimens reported in the literature.

On February 1, 1969, four buck pronghorn (one adult, three juvenile) were killed illegally near Caborca, Mexico, and smuggled to Tucson for mounting. The four skulls, minus skins, were seized by U.S. Game Management agents of the USFWS and

deposited in the National Museum of Natural History (U.S.N.M. #347452-347455). The skulls show similarities to the holotype for sonoriensis and exhibit differences from the other four subspecies (as does the holotype), lending support to the continued recognition of sonoriensis as a valid subspecies of Antilocapra americana. Between 1970 and 1975, three other specimens were found within the Sonoran pronghorn range (AGFD 1981). On June 24, 1970, a dead buck fawn was removed from the Wellton-Mohawk Canal south of Interstate 8; on July 10, 1972, the carcass of an adult buck was found along Ajo Mountain Drive (east of Highway 85) and, in September 1975, an adult doe was hit by an automobile and killed on Highway 2, 8 km west of Sonoyta, Mexico. There is no mention in the literature of any comparative data on these specimens, although the road-kill doe is in the University of Arizona mammal collection. Two collared pronghorn (one buck, one doe) have been lost to various causes during the present study.

B. Taxonomic Description

A. a. Sonoriensis differs from the other four subspecies in size, color and cranial structure (Paradiso and Nowak 1971). Sonoran pronghorn are somewhat smaller and paler, and the cranium is distinctive from the other subspecies'. Molar teeth are shorter and narrower, the rostrum is more slender and the mastoidal breadth and greatest width at the posterior border of the orbits are less. The skull is narrower and more delicately structured. The frontal depression is less pronounced and the auditory bullae are smaller, flatter and project less below the level of the basioccipital. The premaxilla are less extended posteriorly along the median line. In all but three of 54 mexicana, americana and peninsularis skulls examined by Paradiso and Nowak (1971), depression of the palate posterior to the palatine foramine is bordered on both sides by a high and sharp ridge that extends from the anterior edge of the alveolous of the first premolar to the anterior tip of the maxilla. This ridge is lacking in the Sonoran skulls, except in the region immediately anterior to the alveolus of the first premolar. A comparison of the four subspecies' skull measurements are found in Table 1.

The skull description for sonoriensis (Goldman 1945) was based on the type specimen collected in Sonora, Mexico. The doe skull collected from Crittenden, Arizona, seems to be intermediate between sonoriensis and mexicana (Paradiso and Nowak 1971). The mastoidal region is narrow, the frontal depression is poorly developed and the bullae are small, all characteristic of sonoriensis, yet the skull is broad across the orbits and the molar teeth are large, as found in the mexicana subspecies. The three juvenile buck skulls from Caborca are narrower than skulls of comparative age from the other three subspecies, and differ in the same characteristics as the adult buck from Caborca.

Table 1. Cranial measurements of four subspecies of Antilocapra americana. Mean is followed by range (in parenthesis); N = number in sample; SD = standard deviation. From Paradiso and Nowak 1971.

Subspecies	Males			Females		
	Mean(range) (mm)	N	SD	Mean(range) (mm)	N	SD
			Greatest length			
A. a. sonoriensis	281.0			250.8,-----		
A. a. americana	284.2(278.3-197.0)	13	4.68	281.1(268.3-294.0)	6	8.37
A. a. mexicana	276.0,294.0			274.0(268.4-289.0)	5	7.96
A. a. peninsularis	285.1(274.0-298.0)	7	6.64	270.3(261.0-288.0)	6	9.05
			Basilar length			
A. a. sonoriensis	243.2			219.3,-----		
A. a. americana	248.8(243.0-257.9)	12	4.15	246.6(238.5-257.8)	6	6.48
A. a. mexicana	239.4,254.2			239.2(232.1-250.4)	5	6.61
A. a. peninsularis	247.2(238.0-260.1)	7	6.26	238.2(231.5-250.5)	6	6.55
			Occipitonasal length			
A. a. sonoriensis	221.8			192.0,208.3		
A. a. americana	224.0(215.2-237.5)	13	6.62	221.9(209.9-232.2)	5	8.21
A. a. mexicana	220.5,234.2			215.7(207.8-221.2)	6	6.64
A. a. peninsularis	224.9(213.1-235.3)	7	7.54	211.4(199.5-230.5)	6	9.67
			Length of maxillary toothrow			
A. a. sonoriensis	72.0			67.0,68.1		
A. a. americana	73.1(67.0-80.4)	15	2.77	72.1(68.8-75.0)	7	1.91
A. a. mexicana	72.1,71.7,68.7			70.2(67.7-72.2)	6	1.41
A. a. peninsularis	73.6(70.8-80.0)	7	2.98	70.0(65.5-73.0)	6	2.67
			Alveolar length of M3			
A. a. sonoriensis	16.6			15.5,18.3		
A. a. americana	18.6(16.4-22.0)	15	1.67	20.1(16.6-23.5)	7	2.27
A. a. mexicana	17.8,19.3,19.5			17.6(16.0-19.3)	6	1.44
A. a. peninsularis	18.3(15.1-19.9)	7	1.47	17.9(16.3-20.6)	6	1.58
			Breadth of rostrum across M2			
A. a. sonoriensis	65.7			66.7,66.2		
A. a. americana	71.9(67.0-75.7)	14	2.74	71.0(67.0-78.3)	7	3.39
A. a. mexicana	67.0,69.7,72.0			70.0(64.5-71.4)	6	2.44
A. a. peninsularis	69.8(65.2-73.3)	7	2.53	66.5(65.0-67.7)	6	.94
			Mastoidal breadth			
A. a. sonoriensis	77.5			69.2,70.2		
A. a. americana	83.0(77.2-87.9)	14	2.86	75.9(72.5-78.7)	5	2.37
A. a. mexicana	85.2,88.0			74.6(71.7-77.3)	6	1.97
A. a. peninsularis	81.7(80.0-83.2)	7	.98	74.8(72.3-77.8)	6	1.63

Based on the six skulls (two doe [1945] and four bucks [1969]), sonoriensis was thought to be more distinctive from the other three subspecies than they were from each other (Paradiso and Nowak 1971). However, in the 1981 special report by the Arizona Game and Fish Department, recognition of the subspecies designation of sonoriensis is questioned. The authors examined the four buck skulls and concluded that the measurements (as well as the type specimen and Crittenden doe measurements) all fell within the range of values given for other subspecies by Paradiso and Nowak (1971). They conclude that the subspecies classification was unwarranted at that time but agreed further study, both physiological and behavioral, would further clarify the situation. All six cranial measurements fall in the lower end of the ranges; a continued clustering of sonoriensis measurements in the lower ranges could indicate subspecies status is warranted.

C. Biogeographical Location

The range of the Sonoran pronghorn is the plains of central western Sonora, Mexico and north to southwestern Arizona. The historical range is difficult to determine since the subspecies was not described until 1945, many years after the population had declined and marginal populations were extirpated (AGFD 1981). Historically, they are thought to have ranged from Hermosillo to Kino Bay to the south; Highway 15, Mexico to the east; Altar Valley and the Papago Indian Reservation to the north; and Imperial Valley, California, to the west (Fig. 1). During an international boundary survey from 1892-1894, pronghorn were seen in every open valley from Nogales, Mexico, to Yuma, Arizona (Carr 1971). Ajo Valley supported a large population and pronghorn were frequently seen along the Camino del Diablo. Wallace (1965 as noted in Carr 1971) stated that Raphael Pumpelly saw pronghorn in Altar Valley, Arizona. None have been observed there since 1933, and the Indians living in the slopes of the Baboquivari Mountains are thought to be responsible for the pronghorn's disappearance (Arrington 1942 in Carr 1971). In 1907, Hornaday undertook his Pinacate Expedition and saw pronghorn in the Cierro Colorado area of the Pinacate Region at the south end of MacDougall Pass and on the Pinacate Lava Flow.

Presently, Sonoran pronghorn range from Caborca to the south; Mexico Highway 15, and Arizona Highway 85 to the east; U.S. Interstate Highway 8 to the north, and the Lechuquilla Desert to the west (Fig. 2). Only one sighting, in 1976, has occurred north of Interstate 8 in recent years (AGFD 1981) supporting belief that the highway is a barrier to movement to the north. No sightings of Sonoran pronghorn have been recorded on the Papago Indian Reservation for 15 years. Once ideal habitat for the pronghorn, unlimited Indian hunting and excessive grazing have decreased population numbers and degraded the habitat until the reservation could not support a resident pronghorn population (Carr 1971, AGFD 1981).

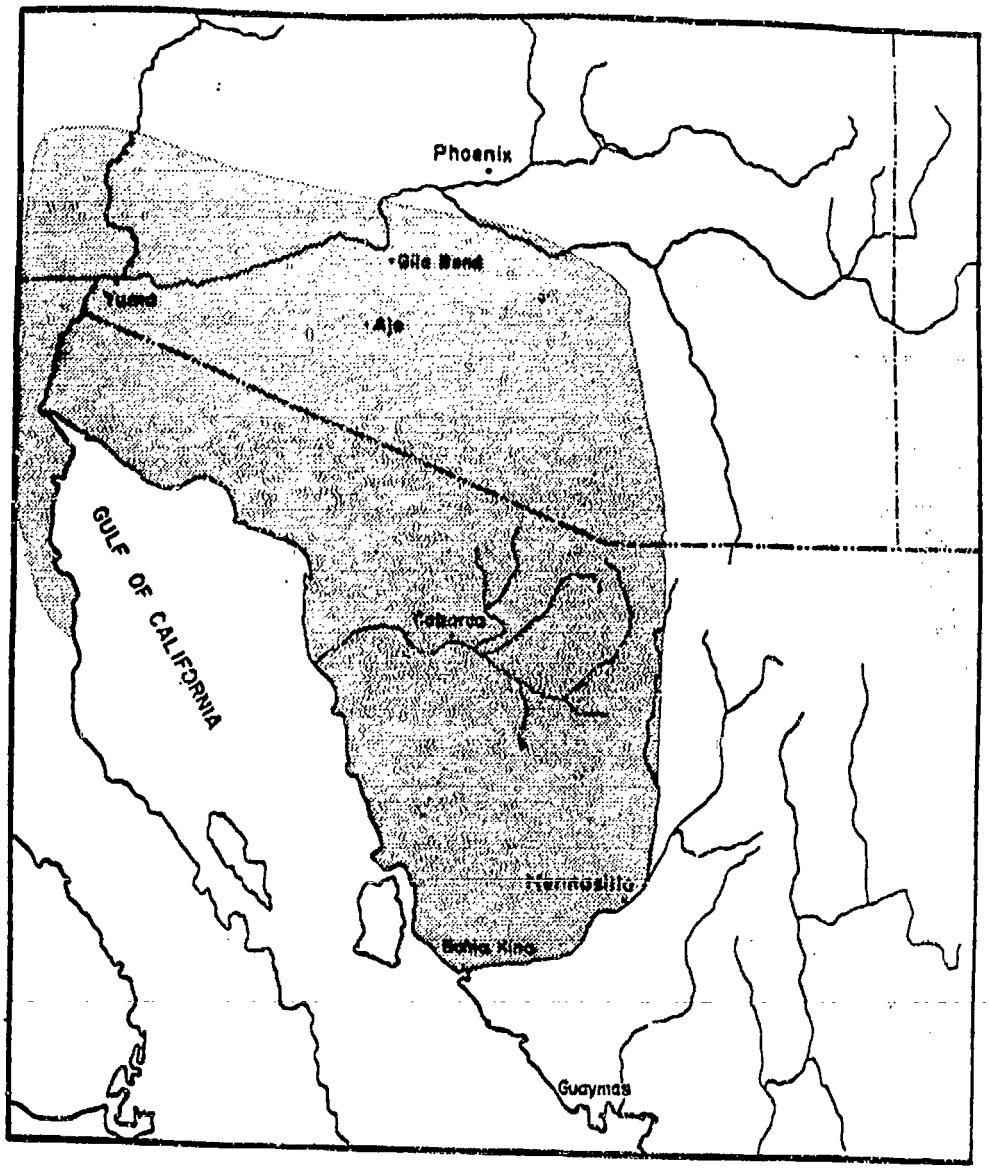


Figure 1. Historic distribution of the Sonoran pronghorn antelope in Arizona and Sonora, Mexico.

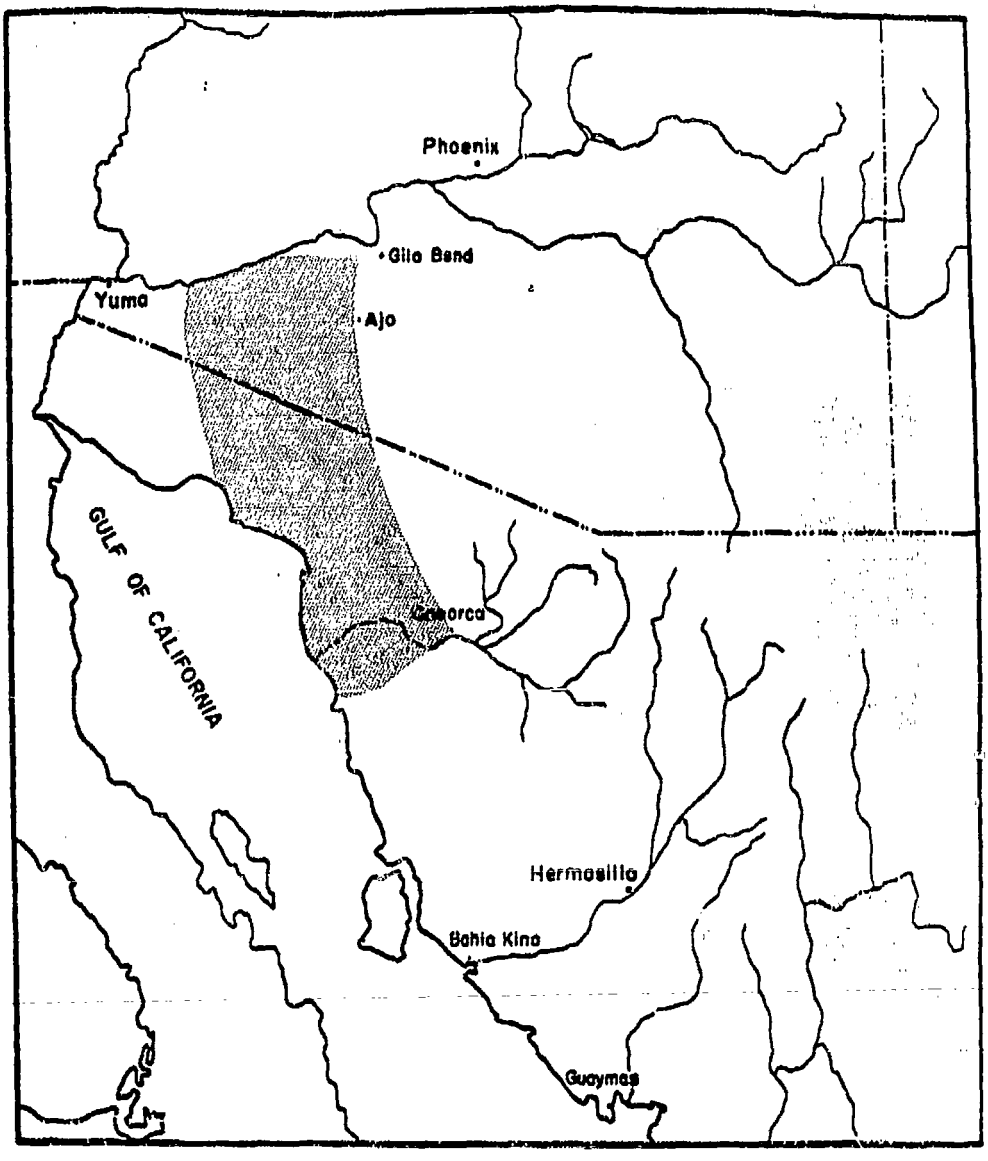


Figure 2. Present distribution of the Sonoran pronghorn antelope in Arizona and Sonora, Mexico.

Pronghorn use patterns have changed within the last 15 years. Carr (1972) noted that the pronghorn were frequently seen in the Pinta Sands area and rarely seen in the Cameron Tanks area, the Growler Valley between the Granite Mountains and the Growler Mountains, in Mohawk Valley between the Sierra Pinta Mountains and Bryan Mountains, in the San Cristobal Valley between the Granite Mountains and Mohawk Mountains, and were infrequently seen on the gunnery range. Present-day sightings in the Growler Valley are very frequent, and Mohawk Valley, San Cristobal Valley and the gunnery range all support bands of 10-20 animals during most of the year. A band of seven to ten pronghorn have been observed in the Cameron Tanks area.

In Mexico, pronghorn range south to Puerto de Lobos. They are frequently sighted on or near the Pinacate Lava Flow or in the open valley between the lava flow and Caborca. A few bands apparently cross the border, but there is no apparent long-range movement or "replenishing" of the Arizona population by the Mexican population, as was previously believed.

D. Population Estimates

The first population estimate for Sonoran pronghorn was made in 1924 (Nelson 1925). Ben Tinker of the Wildlife Protection Fund supplied the USDA with the distribution of pronghorn of Sonora in a 1925 status report. He counted a total of 595 pronghorn in 4 areas in Sonora, and estimated 105 in Arizona (Carr 1969). Nichol (1941) estimated 60 in southwest Arizona (not including OPNM) in 1941; Villa (1958) estimated 1000 in northwest Sonora in 1957, while Halloran estimated less than 100 in Arizona during the previous year. Monson (1968) estimated the Arizona population to be less than 50, but Carr's ground observations (1968-1974) placed the number from 50 to 150. This increase in number estimated is probably the result of increased effort in observing pronghorn.

Currently, it is estimated that there are 200-300 pronghorn in Mexico (AGFD 1981). Results of the present study indicate there are 85-90 in Arizona.

E. Reasons for Population Decline

Several factors contributed to the decline in numbers of the Sonoran pronghorn over the last century. During the late 1800s, farming and irrigation practices and town development along the Gila River and Rio Sonoyta drained the free flowing water, creating intermediate, and often dry, riverbeds (Carr 1972). Cattle ranching was initiated on the game range area, OPNM and LAFBGR, with livestock numbering several thousand at its peak. Drying of the area, coupled with the reduction of vegetation by cattle grazing, caused degradation of the quality of habitat available to the pronghorn. Cattle also competed with the pronghorn for available water. By the

late 1970s, all cattle had been removed from the pronghorn's range. Ranching still occurs in Sonora, where poor range conditions prompted a Sonora resident to report of malnourished pronghorn found dead (Carr 1972). Overall, poor range conditions still appear to be the leading cause in the declination of pronghorn numbers.

Hunting was also prevalent until the 1920s, when it was outlawed. In Arizona, poaching continued but was not viewed as a problem, especially when the majority of the pronghorn's range was converted to a game range, national park and military range between 1939 and 1941. This reduced access to areas frequented by pronghorn. However, poaching in Mexico still occurs despite being unlawful since 1922.

It is difficult to administer protection for the pronghorn in this region. The development of the Mexican citizen conservation group, Patronata para la Protection y Approvectiamiento de la Fauna en el Estado de Sonora, has helped decrease the incidence of poaching in Sonora in the past 15 years, yet it still remains a major limiting factor for the Sonoran pronghorn in Mexico (Carr 1971).

F. Past Management Practices

Protection of the Sonoran pronghorn in the United States was instigated in 1923, when a special game warden (Ben H. Tinker of Arizona) was employed to protect the pronghorn and sheep along the Sonora/Arizona border (the antelope that crossed the Arizona/Mexico border at this time were protected under the Permanent Wildlife Protection Fund) (Carr 1971). His main duty was to patrol for poachers.

Past management practices have mainly been custodial in nature, since the range is divided into three areas controlled by three different agencies. The Cabeza Prieta National Wildlife Refuge has reduced human access and, therefore, reduced possible human impacts in critical pronghorn habitat. They have also maintained, as well as developed, water holes for pronghorn and bighorn sheep. Organ Pipe National Monument has been a wilderness area since 1978 limiting access to the area. Wells have also been maintained. The Luke Air Force Base Gunnery Range (which includes CPNWR and OPNM) has greatly reduced access. The AGFD has access to maintain catchments in the northern tactical ranges.

Protection of critical habitat for the past 45 years has been an important factor in maintaining pronghorn numbers, but equally important was the removal of cattle from CPNWR and OPNM throughout the 1970s. Also important is the continued maintenance and development of accessible water for the pronghorn. In Arizona, the Sonoran pronghorn population has neither increased nor decreased significantly since the 1924 survey conducted by Nelson, yet the dramatic decrease in the

half century prior to that survey (due to water loss and continued habitat destruction) warranted the nomination of the Sonoran pronghorn for the Endangered Species List. On March 11, 1967, the Department of Interior listed the Sonoran pronghorn as endangered (USFWS 1983). Studies were conducted from 1968 to 1972 by the AGFD to determine population numbers, life history and habitat use, and were instrumental in bringing the management problems of the pronghorn to the attention of the land controlling agencies.

In 1982, the USFWS drafted a Sonoran pronghorn recovery plan aimed at proposing ways to maintain existing population numbers and distribution, and developing techniques to increase the U.S. population to 300 animals (an average over a 5-year period) or a number that is feasible for the habitat. When the appropriate number is reached and major threats have been reduced or eliminated, the Sonoran pronghorn would be considered for delisting.

III. STUDY AREA

In Arizona, the Sonoran pronghorn range is on 1 million hectares in the lower southwest corner of the state. The study site covers an area from Interstate 8 on the north, Highway 85 on the east, the international boundary on the south and approximately along the eastern edge of the Sierra Pinta Mountains to the west (Fig. 3). This area is principally managed by three agencies: the U.S. Fish and Wildlife Service (Cabeza Prieta National Wildlife Refuge), the U.S. National Park Service (Organ Pipe National Monument) and the U.S. Air Force (Luke Air Force Base Gunnery Range).

The Cabeza Prieta National Wildlife Refuge covers 348,000 ha from the Ajo Mountains to the Cabeza Prieta Mountains, and from Childs Valley to the international boundary. Ranching and mining were common during the first 40 years of the century, and the Camino del Diablo (Road of the Devil) was a frequently traveled thoroughfare from Caborca to Yuma. In 1939, the Cabeza Prieta Game Range was created by the Department of Interior. Off-road driving was limited to administrative roads, hunting and collecting were prohibited, and cattle were removed from a major portion of the refuge. By 1978, when the area was designated a national wildlife refuge, all cattle were removed. Currently, access to the refuge is by permit only, hunting is limited to four bighorn sheep permits per year, and vehicular travel is still confined to administrative roads. There are approximately 35 tanks, wells, catchments, and natural water holes maintained for wildlife and redevelopment of other closed wells is proposed. Visitor use is low, with only 1000 visitors per year.

Organ Pipe National Monument is a Sonoran desert preserve covering 134,000 ha south of Ajo, and is bordered by Mexico,

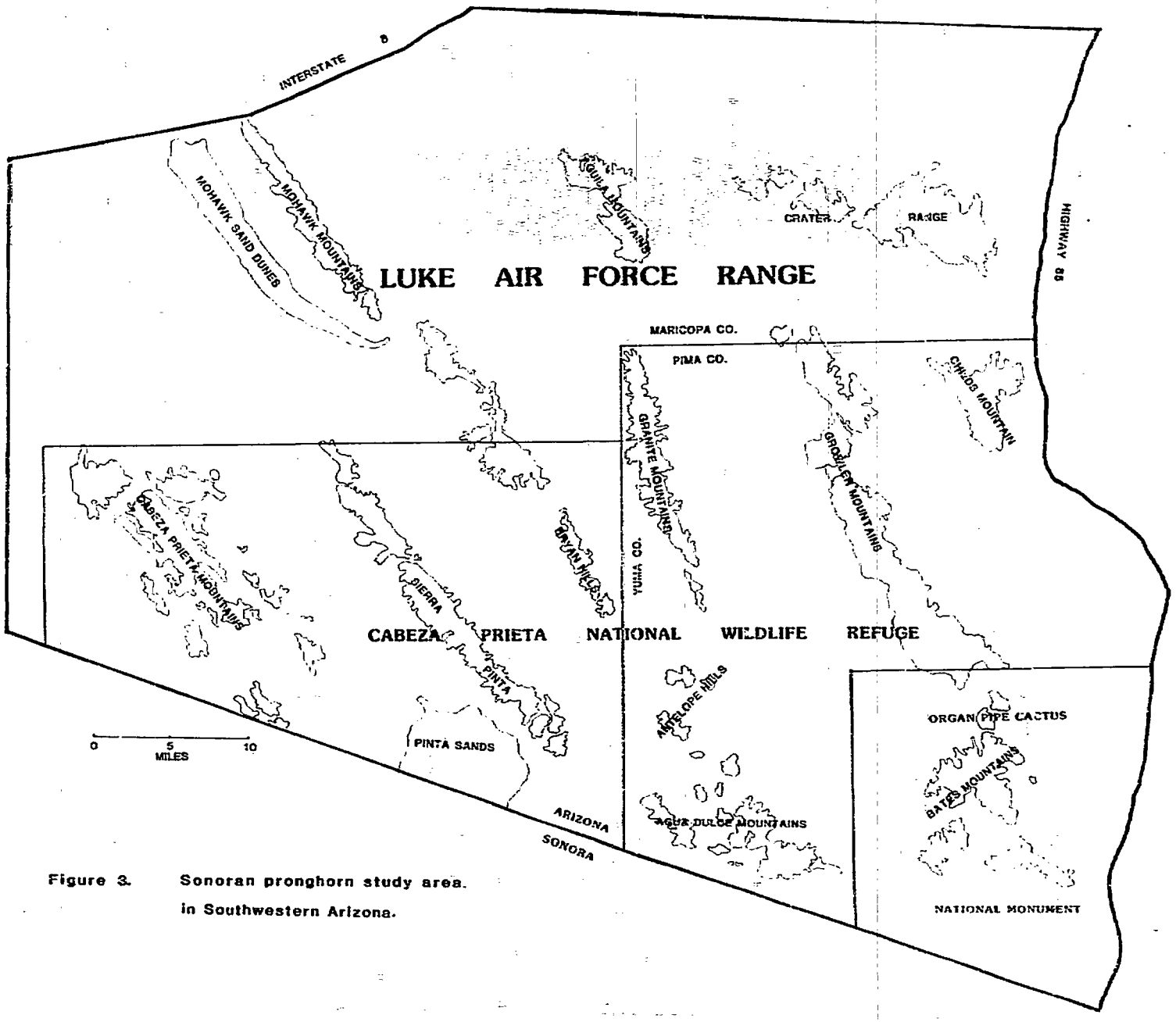


Figure 3. Sonoran pronghorn study area. in Southwestern Arizona.

the Papago Indian Reservation, Cabeza Prieta Refuge and Bureau of Land Management region (NPS no date). The park was established in April 1937, with mining prohibited and grazing rights held exclusively by the Papago Indians in the extreme southwest corner of the Monument and a few individuals scattered over the park. Mining was permitted again in 1941, rights were sold to the government in 1957 and, by 1976, mining was again permitted, but with more strict regulations (NPS/UofA 1981). Grazing rights were ended in 1970, yet trespass grazing continued until 1978, when all cattle were removed from the Monument. Vehicular access is minimal throughout the park and no hunting, collecting or camping (outside of the campground) is allowed.

The Luke Air Force Base Gunnery Range was established in 1941, when 1.1 million ha (including CPNWR) were set aside for military maneuvers (Natural Resource Planning Team, UofA 1984). The range is bordered by Interstate 8 to the north, the Gila Mountains to the west, Mexico to the south, and is bordered along a southwest to northeast line by OPNM and the Papago Indian Reservation. The western sector is administered by the U.S. Marine Corps in Yuma, Arizona, and the eastern sector is administered by the Gila Bend Sector of the Air Force. Within the sectors, there are maneuvering ranges with air-to-ground weapons delivery, tactical air command ranges with target complexes of tanks and convoys, and air-to-air ranges utilizing pilotless drones and towed targets. Mock duels and computer-analyzed flight maneuvering, as well as some major weapons testing in remote areas, occur during part of the year. Public and private access has been greatly reduced (limited hunting is allowed during the fall) and, since all maneuvers are performed from the air, there is little disturbance to the ground. Air-to-ground ordinance, as well as air-to-air ordinance, causes slight damage upon impact and jettisoned 5 m high aluminum targets are embedded across the desert. Every five years the ordinance crews clear the areas of live ordinance, leaving some tracks on the desert pavement. Despite these impacts, Luke Air Force Base Gunnery Range remains one of the southwest's most unspoiled desert regions.

A. Physiography, Geology and Soil

The regional topography typifies that of the Basin and Range physiographic province of the western and southwestern U.S. and northern Mexico (Nations and Stump 1981). The mountains of the area are large-scale block faulted mountains that created ridges separated by wide alluvial valleys. These valleys are partially filled with clay, silt and alluvium deposited from sheet erosion and ephemeral streams. Two types of mountains are found in the region: a sierra type composed of metamorphic rock and granite rock, and a mesa type composed of igneous basalt. The sierra type mountains are extremely narrow, sharp crested and steep sided, arising abruptly with limited foothills (i.e. the Sierra Pinta and Granite

Mountains). The mesa type are also steep sided and rise sharply, but are flat on top and are less rugged (i.e. the Growler Mountains). Alluvial material was transported from the sides of the mountains down canyons; where the material fans out into the valleys from the base of the mountains, where "bajadas" are formed. All mountain ranges in the region (except the Bates and Agua Dulces Mountains) run northwest to southeast, and none except the Ajo Mountains are higher than 915 m.

Mean elevation is from 550 m in the Ajo Valley to 122 m at the northwest end of the Mohawk Mountains. The valleys are fairly level, with drainage to the north and west through a braided wash system in the center of the valleys. On Organ Pipe National Monument, approximately 35% of the monument's rainfall drains to the south into the Rio Sonoyta (NPS 1977). Most of the moisture that falls on the study area is absorbed, with washes running only at the peak of monsoon activity in the late summer.

Several drainage systems are enclosed systems that occasionally fill with water only a few inches deep. These systems at one time were lakes. Evaporation of water and drying of the mud has created beds of hard packed and barren soil. These "playas" produce a carpet of annual forbs after summer rains. Pinta Playa and Dos Playas on the CPNWR are examples.

A large lava flow crosses into the Tule Desert from the Pinacate Peaks (1291 m) in Mexico. The flow covers approximately 32 square kilometers in Arizona. Erosion has created pockets of sandy soil that support vegetative areas of paloverde, mesquite and ephemerals.

Soil types range from sandy loams to coarse, clean sand. Several sand areas, remnants of marine coasts, are found in the central region of the study area. Large sand dunes are found west of the Mohawk Mountains. West of the Aguila Mountains and south of the Sierra Pintas Mountains large sand plains are found. These plains have long been considered ideal pronghorn habitat due to the similarity to Mexican Sonoran pronghorn habitat.

B. Climate

The Sonoran Desert climate is characterized by extreme heat and aridity. Summer temperatures (mid-May to mid-September) range from 38-44°C, with soil temperatures often reaching 75°C (AGFD 1981, Sellers and Hill 1974). The rest of the year, the temperature remains quite comfortable, ranging from 19-25°C. Freezing periods are infrequent in Ajo (elev. 537 m), with freezes starting December 16 and ending February 5. As elevation lowers to the west, freezing periods are more infrequent.

The Sonoran pronghorn habitat is one of the driest areas in the southwest (Table 2). Average annual precipitation is 127 millimeters, falling mainly during the two rainy seasons. May and June are typically the driest months.

From July to September, deep currents of moisture moving across southern Arizona from the Gulf of Mexico and tropical air (from maritime hurricanes) traveling north through the Gulf of California cause quick local thunderstorms. This "monsoon" season causes unpredictable flash floods in the major washes, often cutting off access to various portions of the study area. These rains produce an abundance of annual forbs and grasses.

Winter precipitation (December to February) is a result of Pacific Ocean storms that cover southern California and Arizona. These storms are more widespread, less intense and longer lasting than the summer monsoons. Occasional snow flurries occur, but the snow melts before reaching the ground. Abundant spring annual vegetation and grass production result from these storms.

C. Vegetation

The Sonoran pronghorn are found in one of the most complex and diversified deserts in the United States, the Sonoran Desert (Brown 1982). The flora of this region tends to be a drought-adapted subtropical group of species and, due to the bimodel rainfall pattern, displays a greater diversity than surrounding deserts. Shreve and Wiggins (1951) recognize seven subdivisions in this desert; the study site is characterized by two of the subdivisions, the Arizona Upland subdivision (AU) and the Lower Colorado River Valley subdivision (LCRV).

The majority of the study site is classified as LCRV. This subdivision is characterized by high temperatures, low precipitation, and generally a single plant species in open valleys, playas and dunes (Brown 1982). Along drainageways, trees and shrubs are scattered along the course.

The most widespread and important community in the LCRV is the creosote (Larrea tridentata)/white bursage (Ambrosia dumosa) association (Brown 1982). Creosote is ~~scattered~~ throughout the valleys up onto the bajadas and is found in higher elevations. White bursage is found in association with creosote on the valley floors, but tends to thin out in the bajada regions. In sandier areas, big galleta (Hilaria rigida) and indigo bush (Psorothamnus schottii) appear. Creosote disappears ~~completely in the sandy plain in~~ North San Cristobal Valley where white bursage is the dominant species.

Along drainageways, larger shrubs and trees are found. Trees that require a higher moisture content, blue paloverde (Cercidium floridum), mesquite (~~Prosopis~~ juliflora) and ironwood (Olneya tesota), are commonly seen.

Table 2. Climatological summary of weather stations surrounding Sonoran pronghorn habitat in southwestern Arizona. From Sellers and Green 1974.

	Temperature C° (mean)								Total Precipitation, mean millimeters			
	Daily Maximum				Daily Minimum							
	Jan	Apr	Jul	Oct	Jan	Apr	Jul	Oct	Jan	Apr	Jul	Oct
Ajo	17.9	28.1	39.9	31.3	5.0	13.2	26.0	16.5	17.8	8.4	34.5	13.0
OPNM	19.6	28.9	39.6	31.5	3.0	9.5	23.2	13.1	19.3	5.7	34.5	17.3
Mohawk	20.8	32.3	44.2	34.4	5.5	22.9	35.7	25.0	8.4	7.6	12.2	4.3
Wellton	20.2	30.2	41.3	32.8	1.4	10.2	24.5	12.7	10.4	3.3	8.1	7.6

Other species represented and commonly found in the LCRV subdivision are the cacti, silver cholla (Opuntia wigginsii), teddy bear cholla (O. bigelovii), Engelmann hedgehog (Echinocereus engelmannii), and compass barrel cactus (Ferocactus acanthodes).

The Arizona Upland division is found along the eastern border of the study site. Although creosote and bursage are still found in this subdivision, the appearance of the vegetation is more like a scrubland of trees, scrubs and cacti. Blue paloverde, ironwood, mesquite, and cat-claw acacia (Acacia greggii) are found in the lower regions, whereas foothill paloverde (Cercidium microphyllum) and crucifixion thorn (Canotia holacantha) are found in the upper, northern regions. Mixed cacti are an important community in this subdivision; thornber buckhorn cholla (Opuntia acanthocarpa var. thornberi), staghorn cholla (O. versicolor), chain-fruit cholla (O. fulgida), teddy bear cholla, saguaro (Carnegiea gigantia), organ pipe (Stenocereus thurberi), and ocotillo (Fouquieria splendens) are common. The bajadas and low foothills are characterized by a paloverde-mixed-cacti scrub series of this subdivision.

D. Water Sources

Before the turn of the century, two rivers flowed in the Sonoran pronghorn's range; to the north was the Gila River, to the south (in Mexico) was the Rio Sonoyta (Carr 1972). Both were thought to be important watering areas for the pronghorn, as well as providing large areas of forage for wildlife (Carr 1972). Development of the towns of Gila Bend and Sonoyta along the rivers led to large farming and ranching practices, ground water pumps and dams along the water courses. As a result, these rivers were dry for many years. Presently, the Rio Sonoyta runs intermittently and the Gila runs more frequently; since 1977, increased rainfall has increased the incidence of flooding along the Gila flood plain.

Two natural springs are found within the pronghorn's range. Quitobaquito Springs, in the Quitobaquito Hills in southwest Organ Pipe National Monument, was once a popular watering hole, not only for wildlife but for Indians, ranchers and travelers. Present availability of the springs is reduced now that the Park Service has a public-use area adjacent to the spring. Baker Tanks is 13 km southeast of Wellton between Baker Peaks and the Copper Mountains on the valley floor. It was once used by ranchers, Indians and wildlife; construction of a picnic area adjacent to the tank has decreased its availability to the pronghorn.

Scattered over the study area are developed catchments, tanks, water holes, natural seeps, potholes and tanks. Approximately half of these are available to the pronghorn (Fig. 4); the remainder are located in inaccessible areas in

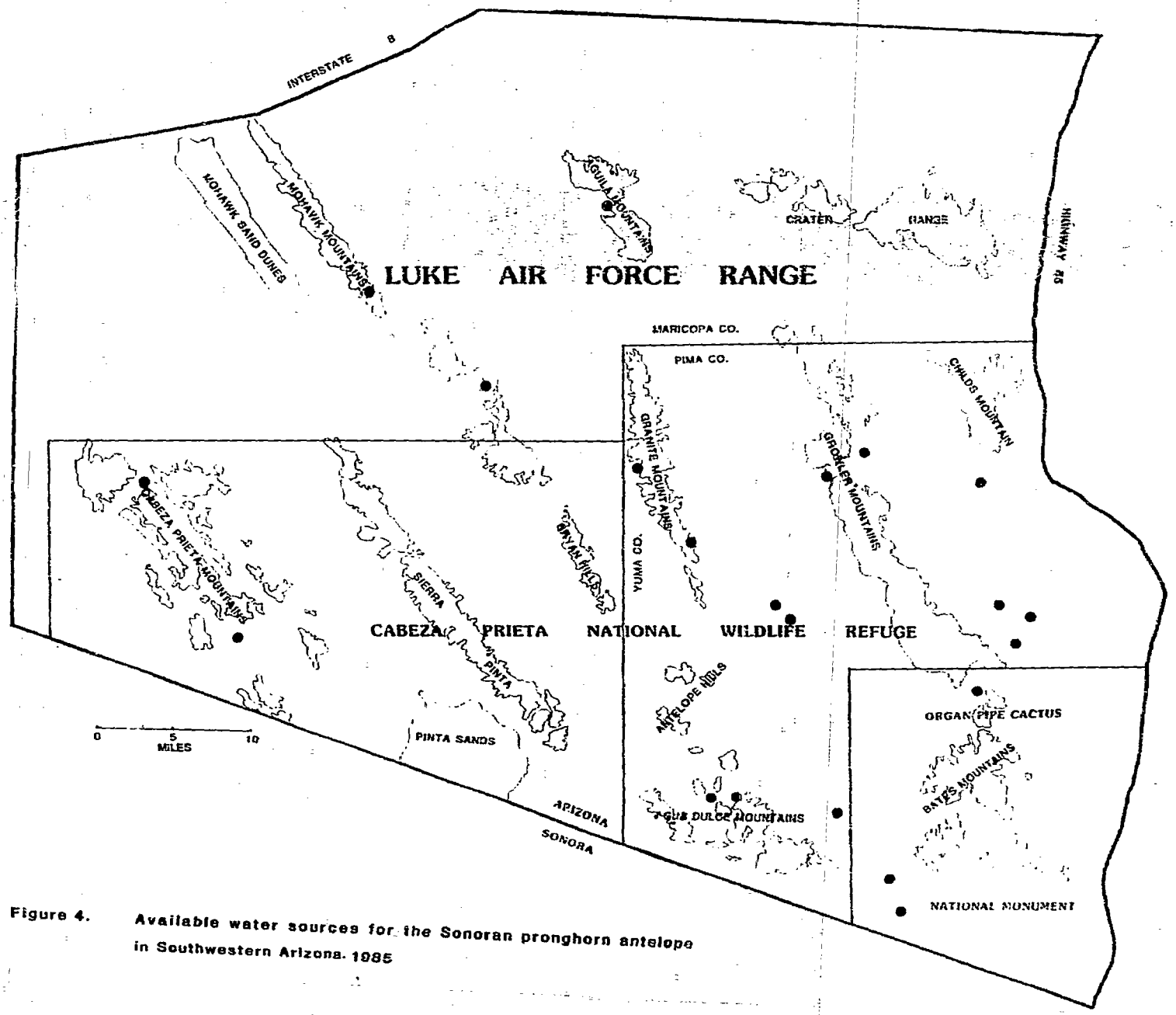


Figure 4. Available water sources for the Sonoran pronghorn antelope in Southwestern Arizona. 1985

the mountains or are dry most of the year. On OPNM, pronghorn have been sighted near Pozo Nuevo Well, Bates Well and Cipriano Well; tracks have been sighted near the AGFD water catchment on the west side of Aguila Mountains on the gunnery range. The majority of available watering sites are on the CPNWR. The USFWS maintains wells at Papago and Charlie Bell Wells (both abandoned ranches), Tule and Little Tule Wells, Jose Juan Tank, Jack's Well, Redtail Tank, the newly refurbished Adobe Windmill and a dozen other small, intermediate tanks and potholes. A half dozen cattle tanks are also found along the eastern border of the pronghorn's range, and the Wellton-Mohawk Canal (where two Sonoran pronghorn have been retrieved) is located along the northern boundary.

The USFWS is currently considering reopening wells on the refuge in areas that support herds of seven to ten animals each. A catchment for seasonal rainfall is also under consideration on the military range.

IV. METHODS

The primary objective of this study, as stated in the study proposal of June 1983, is to "obtain basic information that will contribute toward the development of a management plan to ensure the continued existence for the endangered Sonoran Pronghorn." Documentation of life history, natality and mortality, and population movements and dynamics should provide some insight into the dispute on the taxonomic classification of the Sonoran pronghorn; development of a capture technique that would reduce mortality and injury was also desired.

A. Sampling

After reviewing the distribution maps compiled in the most recent field study of Sonoran pronghorn (AGFD 1981), the decision was made to capture pronghorn from four different areas. They are as follows:

1. Pinta Sands north of the Tule Desert
2. North of the Agua Dulce Mountains, east of Papago Well
3. East of the Aguila Mountains in the Childs Valley
4. Growler Valley, west of the Growler Mountains

The capture was conducted from October 28-30, 1983. In order to facilitate location of pronghorn, two fixed-wing aircraft were used. Once pronghorn were sited, a capture helicopter was called and the animal was captured.

A handheld net gun was employed for capturing the pronghorn; this avoided the use of tranquilizer darts and drug related risks to the animals. The three-barreled gun shot a triangular net, 19 feet on each side, over the pronghorn's back. The entangled animal was held for not more than five minutes; a radio collar was fitted, and blood samples and body measurements were taken during that time period. Chase time and capture time were held to a minimum and, as a result, no animals were lost during the capture. Net gun services were provided by Far West Humane Animal Capture, Mesa, Arizona.

Biotelemetry collars that weigh ten ounces (or approximately one percent of the pronghorn's weight) were used. In order to use a smaller battery on the transmitter, photoelectric cells were used on seven collars to increase battery life. All transmitters have a normal pulse rate of 55 beeps per minute; at night, the photocells reduce the transmitter to four beeps per minute. The mortality sensor on all collars is 15 beeps per minute, with a one-hour time lapse from active to mortality signal. Life expectancy on the regular collars is 12-18 months and 36-40 months for the photocell collars. All collars are still active at this time.

B. Field Techniques

In order to obtain the information needed to manage the Sonoran pronghorn, four field techniques were employed; weekly aerial relocations, ground relocations, placement and monthly reading of 38 rain gauges, and vegetation transects were conducted at sites of aerial relocation.

1. **Aerial Relocation**

Aerial relocation of the collared pronghorn occurred on a weekly basis, providing clearance was obtained from Luke Air Force Base Command Post (military maneuvers are scheduled weekly; time was allotted on weekends for air space for this study). A small single-engine aircraft equipped with a belly antenna and a Telonics TS-2 receiver with scanner was used for relocations (LeCount and Carrel 1979). Once the signal was picked up, 10 to 15 minutes was spent pinpointing the signal and obtaining a visual of the pronghorn. To prevent stress, no animal was followed longer than 15 minutes. All pronghorn observed were aged and sexed. Actual locations were located on a USGS topographic map and recorded as Universal Transverse Mercator (UTM) coordinates.

2. **Ground Relocation**

Effort was made to relocate selected collared pronghorn several times ~~during the~~ weekly. Selection was made for those pronghorn located in areas with access or in areas where military clearance could be obtained. Once the pronghorn's signal was pinpointed, a spotting scope and 10X50 binoculars

were used to observe the pronghorn's behavior. Observations were made from low hills within a kilometer of the pronghorn. In order to reduce the stress on pronghorn, a distance of at least 350-500 m was maintained between the pronghorn and observer. Group composition and behavior was documented every two minutes for as long as visual sightings could be kept. When visuals were not obtained, signal strength, pulse rate and azimuth were recorded to determine habitat use. Pronghorn without photocell collars were tracked at night to document nocturnal and crepuscular movements.

When possible, fecal samples were collected from areas used by the pronghorn, and vegetation samples were obtained from plants pronghorn were observed browsing. Observations of tracks and buck rut-related scrape and void markings were documented and photographed.

All ground and aerial locations were mapped on a USGS topographic map. Each site was assigned a UTM coordinate, locating the site within a 200 square meter area. For each location, 12 variables were noted on a standardized field data sheet (Figs. 5 and 6): date, observer, time of observation, length of observation, UTM coordinate, vegetation type, group size and composition, behavior or activity, weather, military activity, proximity to water and type of water source, and vegetation transect number.

3. Rain Gauges

Rainfall was calculated from 38 rain gauges placed every 8 km along the administrative roads on eastern CPNWR, western OPNM and southern LAFB gunnery range. Seven-foot posts were placed approximately 20 m from the road, and plastic gauges with .05-inch gradations were affixed to the fence posts. A layer of motor oil or transmission fluid was placed in each gauge to prevent evaporation, and the gauges were read on a regular basis. The gauges were lashed to the posts to prevent raptors from tipping the gauges out of their brackets. Gauges were tagged with a USFWS bird band and AGFD tags for identification.

4. Vegetation Transects

To identify the habitat utilized by the pronghorn, vegetation transects were identified on sites of aerial relocation of the collared pronghorn. Five sites from the four areas where pronghorn were collared in (Military Range, Mohawk Valley to Papago Well, Growler Valley and OPNM) were randomly selected each month. At each site, a 100-meter-long line intercept transect (Lucus and Seber, 1978) and a MacArthur board technique (MacArthur and MacArthur 1961) will be utilized. Fecal count of big game and predators are also conducted along the lines. Each site is assigned a number, and numbers and transect data is recorded on a standardized chart.

Collaring Data:

Animal #_____ Sex:_____ Age:_____

Date Collared:_____ Area Collared:_____ UTM:_____ Group Composition:_____

Additional Information:_____ Photocell?:_____

Date	Type	Obs.	Time	Length	UTM_{15} Coord.	Veg. Type	Elev.(ft)	Grp Comp, SX	Activity	Weather	Rel. Act.	Prox H_2O	Type H_2O	VI

Figure 5. Chart for recording data on radio collared Sonoran pronghorn.

I Date: date of observation.

II Type: type of observation.
1) A-aerial
2) G-ground

III Observation: observer's initials or GF number.

IV Time: time first sighted or time first sig. / time first obs.

V Length: length of time between--
1) first receiving signal to end of observation (Ground)
2) first approximate location of animal to 10 minutes, visual or not (Aerial)

VI UTM_{15} Coordinates: EN coordinates when--

1) first sighted (Ground)
2) first sighted or location [illegible] (Aerial)

VII Vegetation Type: major vegetation type(s) utilized during observation (Brown).

VIII Elevation: elevation of animal, in feet.

IX Group Composition: composition of group (age & sex) minus focal animal.

A. Ages	B. Sex	C. No visual = ---
1) A-adult	1) -male	
2) J-juvenile	2) -female	
3) F-fawn		

X Activity: general activity(s) during observation.
A. Types
1) 1:1-no visual, but active signal
2) W-walking (w/N,S,E,W direction designation)
3) B-browsing
4) RO-run from observer
5) I-inactive rest or daytime bed
6) C-rut behavior
7) D-male display
8) S-stand/stare

XI Weather: predominent weather during observation.
A. Types
1) S-sunny
2) Cr-clear
3) Cl-cloudy
4) R-rain, thunderstorms
5) W-windy

XII Military Activity: activity during observation in area of observation.
A. Types
1) + = yes
2) - = no

XIII Prox. to H_2O: in km, proximity to known source of permanent H_2O (seasonal listed for monsoon months).
1) km to source
2) = exceeds 15 km or unknown

XIV Type H_2O: type or water source (seasonal listed for monsoon months).
A. Types
1) T-tank or charrco
2) W-windmill trough
3) L-well
4) S-seasonal free standing (washes, etc.)

XV Vegetation Transects (VT).
1) x = no
2) #____ = transect form #

Figure 6. Chart variables for recording data on radio collared Sonoran pronghorn. Arizona Game & Fish Dept.

V. RESULTS AND DISCUSSION

A. Capture Results

Four bucks and six does were captured and collared. One buck was collared south of the Aguila Mountains, one buck was collared west of Charlie Bell Pass in North Growler Valley, two does were collared in the Daniels Arroyo east of the Growler Mountains, one buck and one doe were collared southwest of the Growler Mountains, two does were collared in the upper San Cristobal Valley, one buck was collared in the lower Growler Valley, and one doe was collared in the middle of Growler Valley.

The captures went without serious incident. Blood and fecal samples and ear, nasal and vaginal swabs were obtained when possible and body measurements were taken if the animal appeared unstressed. Body temperatures remained 41°C or less (normal - 38°C) yet a few pronghorn exhibited signs of some stress; measurements were taken from seven pronghorn (Table 3). Analysis of seven blood samples did not show any remarkable differences, and analysis of fecal pellets, parasites, hair samples and nasal, vaginal and ear swabs also proved unremarkable.

B. Field Results

Information from aerial and ground relocation show the Sonoran pronghorn is behaviorally unlike the other three subspecies. This is reflected in group size and composition on a seasonal basis, natality, home ranges, and foraging and watering habits. These differences reflect an adaption to the harsh environment these pronghorn inhabit.

A full-time field technician was hired in June 1984, initiating weekly aerial and ground relocations. Aerial data was obtained during 33 telemetry flights (or 268 relocations of 10 collared pronghorn), from November 5, 1983 to March 16, 1985. With the exception of buck #149.100, which died prior to July 13, 1985, all animals were relocated 27 to 31 times (equipment failure or minimal [or no] military clearance prohibited complete relocations for all animals). Ground data was obtained during 46 relocations from March 30, 1984 to March 2, 1985.

Rain gauges have been checked monthly since their installment in July 1984, and vegetation transects are currently being conducted.

The following is a general summary of the collared pronghorn.

Table 3. Body measurements of seven collared Sonoran pronghorn, October 1983.

Sex & No.	Hind Foot (mm)	Total Length (mm)	Tail Length (mm)	Ear Length (mm)	Shoulder Height (mm)	Chest Girth (mm)	Neck (mm)
F 149.081	391	1384	122	152	787	749	302
M 149.100	---	1511	114	178	---	876	---
F 149.201	427	1524	117	157	909	859	302
F 149.250	---	1428	102	152	800	846	305
F 149.260	---	---	---	---	808	744	302
F 149.311	---	1461	102	157	851	897	376
M 149.380	---	1359	---	---	757	775	277

#149.081

This 1-1/2-year-old doe was collared in middle Growler Valley. She has remained in the region southwest of the Growler Mountains, within range of Redtail and Parra Tanks and was aerially relocated 31 times. In December 1984, she was relocated (along with doe #149.311) in the largest herd seen in this study, 21 individuals. She prefers the open creosote/bursage habitat and was occasionally relocated alongside washes. On two occasions, she was found in the bajada/foothill area near Growler Mountains. She remains within 2 to 10 km of a permanent water source.

#149.100

This adult male was collared and relocated seven times at the southern end of the Growler Mountains on OPNM. He used the bajadas and creosote/bursage flats equally. He remained within 5 km of a permanent water source. His skeletal remains were located on July 13, 1984, along a wash running through a bajada.

#149.201

This adult doe was collared in San Cristobal Valley and remained in the northern end of San Cristobal Valley and Mohawk Valley and was relocated 27 times. She was relocated during the winter 1984/85 with doe #149.260. She preferred the creosote/bursage association, but has been located infrequently in the creosote/bursage/mixed cacti foothills. She remained within 2 to 10 km of a catchment.

#149.221

This 6-year-old buck was collared in the southern foothills of the Aguila Mountains and was relocated 31 times. He is often solitary and has been relocated approximately 1/3 of the time on a mock airfield in the south TAC impact area of the gunnery range. The remainder of his time is spent ranging through Childs Valley down to Ajo Mountain. He was observed in a herd of 17 during the winter of 1984-85. He prefers the creosote/bursage association and has been located near washes or on foothills several times. He remains 10 to 20 km from permanent water.

#149.250

This adult doe was collared with doe #149.290 in the Daniels Arroyo/Cameron Charco region and was relocated 28 times. This region is the highest elevation in which the pronghorn have been found (550 m). She was located in a herd of four to five does and three bucks; the herd remained in a 5 km triangular area throughout the year. This area is a mixture of habitat types (creosote/bursage flats, rolling

foothills, washes, and bajadas) and has three permanent water sources (two wells and one stock tank). A fence crosses the eastern edge of the region and there is moderate human and cattle traffic on the BLM side of the fence. She preferred the creosote flats, yet has been located in the other habitat types as well. She remains within 3 km of a permanent water source. The herd had become very tolerant of the observer and airplane; they usually remained still during aerial relocation and ground relocation 50 m away created minimal disturbance. She had twin fawning in spring 1984 and spring 1985. She was found dead in March 1985.

#149.260

This 1-1/2-year-old doe was collared in San Cristobal Valley and is the widest ranging of the does. She was relocated 29 times. During the winter months, she was found with doe #149.201 in north San Cristobal Valley or in north Mohawk Valley; during the summer, she was located around Papago Well and Antelope Hills. The remaining seasons found her in long-range movement between these two areas. She prefers the creosote/bursage association half the year and the bajada/foothill region the remainder of the year. She also remains 2 to 10 km from permanent water (except during her long-range movements).

#149.281

This 5-year-old buck was collared on OPNM and was relocated 28 times. He remained in Arizona until May 1984, when he was located on the Pinacate Lava Flow in Mexico. No relocation was obtained until August 1984, when he was relocated along the eastern border of OPNM with four does. He has remained in this area since that time preferring the creosote flats surrounding the low volcanic hills in western OPNM, but has been relocated on a 460 m hill or in the dense ephemeral wash area adjacent to the volcanic hill. He remains 1 to 5 km from a permanent water source.

#149.290

This yearling doe was collared with #149.250 in the Daniels Arroyo/Cameron Charco area. She was relocated 27 times. She remains in this area to date. She has been consistently located in association with a small herd of pronghorn including #149.250.

#149.311

This adult doe was collared in OPNM south of Growler Mountain and was relocated 31 times. She uses the area from Redtail Tank in Growler Valley to the foothills of Bates Mountains. She was observed with doe #149.081 during the winter and was part of the herd of 21 individuals located

December 15, 1984. She prefers the creosote flats for most of the year and uses the bajada/foothill region between the Growler Mountains and Bates Mountains for fawning. She remains 2 to 7 km from permanent water. She was observed with twin fawns in spring 1984 and spring 1985. She was the largest and oldest doe captured.

#149.380

This yearling buck was collared west of Charlie Bell Pass in the Growler Mountains and was relocated 28 times. He has ranged from south of Dateland (Aztec Hills) to the Mohawk Mountains during fall and winter, then south to Charlie Bell Pass in the Growler Mountains during the summer, ranging the furthest of the bucks. He prefers the creosote/bursage association most of the year and has been located in the bajada regions during the spring. He also remains 2 to 12 km from a water source.

C. Group Size

Throughout northern Arizona, herds of A. a. americana numbering 30 or 40 to 100 individuals are frequently seen. In Wyoming, these pronghorn congregate into herds of 1000 or more animals during certain seasons (Kitchen and O'Gara 1982). In contrast, the Sonoran pronghorn is often seen in a "herd" of three or four pronghorn. A definite seasonal group size is evident in sonoriensis; generally large congregations are found during late fall and winter. These large groups begin to fragment in late winter with solitary pronghorn being common during the spring. Medium size groups (3-7) are found during summer and early fall. Table 4 lists herd sizes of collared pronghorn observed from October 1983 to March 1985.

The smallest group size observed was a solitary pronghorn with all but one of the collared pronghorn were observed solitarily at least once; yearling doe #149.290 was not observed solitarily during this period. The largest group size observed was 21 pronghorn located with two does, #149.081 and #149.311, in the lower Growler Valley on December 15, 1984. Mean group size observed during this study is 5.74 (SD = 0.91) animals.

Total number of pronghorn seen during a telemetry flight varied. During summer months, visuals are difficult; the small herds have a tendency to bed under mesquite trees or stand near larger bushes and trees, and avoid running in the heat. Visuals are easily obtained from September until May; unassociated uncollared pronghorn were also observed during several winter flights.

A total population estimate of 85-90 Sonoran pronghorn was made based on aerial and ground observations on most of CPNWR, OPNM and LAFBGR during the weeks of December 15 to December 30,

Table 4. Herd sizes associated with collared Sonoran pronghorn, October 1983 to March 1985.

Individual Sex & No.	N	Smallest	Largest	Mean	Standard Deviation
F 149.081	31	Solitary	21	7.25	4.80
M 149.100	7	"	8	4.30	3.51
F 149.201	27	"	8	6.00	1.97
M 149.221	31	"	17	6.06	6.17
F 149.250	28	"	7	6.38	.96
F 149.260	29	"	8	5.83	2.41
M 149.281	28	"	10	4.39	2.06
F 149.290	27	4	7	6.38	.96
F 149.311	32	Solitary	21	5.58	5.10
M 149.380	28	"	13	5.20	3.85

Mean herd size	Smallest	Largest
mean	1.3	12
standard deviation	.95	5.68

1984. Due to the congregation of herds, the great distances between herds and little change in group composition or size, this estimate reflects little, if any, duplication in count. Fifty-six pronghorn were sighted during a single telemetry flight, 7 others were known to be in mid-Growler Valley, but unassociated with any collared pronghorn in the area, and 20 other uncollared pronghorn were observed by AGFD personnel, USFWS personnel and U.S. Border Patrol agents during that period. This number reflects one of the first unduplicated counts done on sonoriensis, yet it concurs with previous population estimates.

D. Group Composition

Sonoran pronghorn group sex and age composition remains similar year-round (with the exception of spring); group size is the only fluctuating variable. During the months of February-March, does separate from the large winter herds and return to fawning areas; they remain solitary or with one or two other does and associated fawns. As early as April, bucks were observed associating with does and fawns. By early summer, herds are composed of two or three bucks and three or four does. Occasionally, solitary bucks or small groups of bucks (2-3) are seen during the spring and summer. Buck #149.221 has been observed alone frequently during telemetry flights; doe #149.081 was observed with five bucks in February 1985.

Carr (1973) estimated the sex ratio of Sonoran pronghorn to be 56:100:28 (n=493) on the Cabeza Prieta National Wildlife Refuge during a five-year period. Current sex ratio estimates are 55:100:42 (n=208 based on observations from December 15, 1984 to January 5, 1985); fawn ratio may increase as more pronghorn band together and are sighted during the latter part of the summer. These ratios fall in the middle range of pronghorn sex ratios (20:1.000 to 91:100) estimated by Kitchen (1974).

E. Home Ranges

Kitchen and O'Gara (1982) have noted the large variation in home range size found within the five subspecies is due to variability in habitat quality, past history of grazing, population and group sizes, and season. Based upon the estimated home ranges from this study, Sonoran pronghorn use areas in excess of those reported for other pronghorn subspecies (Table 5; Appendix A).

The Sonoran pronghorn exhibit definite seasonal habitat use patterns. During the winter, pronghorn congregate into larger bands and often were found in the northern portion of the study area. Movements were restricted during the winter with use areas estimated between 1.3 and 26.0 square kilometers. Long-range movements were observed during early

Table 5. Home ranges of individually collared Sonoran pronghorn, October 1983 to March 1985.

Sex & No.	Home range area (km^2)	Max. linear distance across home range(km)	Max. distance from capture site(km)
F 149.081	220.85	25.00	26.00
M 149.100	60.87	37.00	31.00
F 149.201	249.39	40.00	22.00
M 149.221	142.75	35.00	35.00
F 149.250	22.16	15.00	8.00
F 149.260	512.76	58.50	45.00
M 149.281	502.91	43.00	40.00
F 149.290	21.00	15.00	8.00
F 149.311	142.43	21.00	16.00
M 149.380	365.08	47.80	36.00

Male and female home ranges (average)

	Home Range (km^2)	Standard Deviation	Max. linear distance(km)	S.D.	Max. distance from capture(km)	S.D.
male	269.6	205.37	40.70	5.83	35.50	3.7
female	194.8	183.04	29.08	17.11	20.83	13.89

summer and fall. One buck (#149.380) traveled 37 km in one week, returning to the original location the next week; one doe (#149.260) traveled a distance of 45 km from her winter range to her summer range during the early part of the summer; buck #149.221 traveled 29 km from his winter range to his summer range in early summer.

Bucks averaged larger home ranges than the does, and ranged slightly further than the does during the long-range movements (Appendix B). Bucks averaged slightly longer movements away from their capture sites.

Doe #149.260 exhibited the most movement of the collared pronghorn. Buck #149.281 has a large range due to his movement into Mexico in spring 1984. It is interesting to note that the two does (#149.250 and #149.290) have remained fairly sedentary since their capture. The herd's one "long" movement (8.0 km) was apparently due to heavy human traffic in their usual range. This herd has available to it three water sources and a variety of habitat types within a 5 km triangle, and exhibits similar ranging behaviors to A. a. americana herds.

F. Movement

The Sonoran pronghorn is widely scattered over the entire study area; seasonal movement appears to be in relation to water availability. Winter herds are found slightly further north than during the rest of the year, and use the creosote/bursage flats more frequently than during the rest of the year. Growler Valley, San Cristobal Valley and upper Childs Valley were the preferred areas during the winter months. Spring movements tended to be in a southerly direction, towards areas with permanent water sources. During the summer, creosote/bursage flats and paloverde/mixed-cacti foothills were both used, with the Lower Childs Valley, lower Growler Valley and lower Mohawk Valley being the preferred areas. During hotter periods of the day, pronghorn used densely vegetated ephemeral washes almost exclusively. Fall movements were long ranging and multidirectional resulting in the use of the upper valleys mentioned above.

G. Natality

Prior to this study, little was known about the reproductive behavior of the Sonoran pronghorn other than the fawn drop was during the early spring (Phelps 1974). Pronghorn does usually become sexually mature at 16 months and bucks are capable of breeding at 1 year (Kitchen and O'Gara 1982). Other subspecies go through rut during the fall and fawn during the summer to take advantage of temperate weather and summer browse. Gestation for all subspecies is approximately 240 days (Asdell 1946).

Does have been observed with fawns from February through May during previous studies. Parturition in February-May places rut during July, August and September, the hottest part of the year. Despite the stress of summer rutting on pronghorn, spring drop is desirable so as to coincide with temperate weather and spring forage. Fawns have been infrequently observed at other times of the year (mainly summer or early fall). This may be due to the exceptional weather patterns (and resulting forage) the state has been experiencing the last six years.

An adult buck, associated with two does (#149.250 and #149.290), was observed in rut in July and August 1984. He frequently left scrape and void markings, and displayed several times at the observer when she approached too close to the herd. No copulations were observed; however, three of the four does in the herd were observed with fawns in spring 1985.

Two does, #149.250 and #149.311, were each observed with twin fawns in March 1984. Both of #149.250's fawns survived (one buck and one doe) and remained with her until February 1985. On February 23, 1985, #149.250 was observed in the low foothills east of Growler Mountains with twin fawns, approximately two to three days old. Five days later only one doe fawn remained with #149.250. On March 2, 1985, a mortality signal was received during a telemetry flight on #149.250; her carcass was found on top of a hill. The fawn was still alive and was observed for 45 minutes prior to finding the carcass. The fawn was was distressed, milled about, looked towards the area where the carcass was, called occasionally, then finally bedded down under a creosote bush. An attempt was made to capture the fawn by hand but eluded capture. Later attempts to find the fawn were futile.

In March 1984, doe #149.311 was observed with twin fawns in the low foothills north of Bates Mountains on OPNM. During aerial relocation in August 1984, she was observed with only one doe fawn. This fawn remained with her until the end of March 1985, when #149.311 was observed with twin fawns in the Bates Mountains foothills again.

Five uncollared does with eight fawns were observed in spring 1985. As of March 16, 1985, 12 fawns have been observed; 1 of these fawns has not been observed since its initial sighting, and 2 are known to be dead.

H. Mortality

Hunting and poaching are the greatest cause of mortality in the pronghorn species in most areas. Predation by coyotes (Canis latrans), bobcats (Felis rufus), and golden eagles (Aquila chrysaetos) have a marked effect on fawn survival (Kitchen and O'Gara 1982). Several diseases and parasites have been diagnosed in the pronghorn species; epizootic hemorrhagic

disease, blue tongue, necrobacillus, vibrioses and nematodes, cestodes, tremalodes and ticks are some of the diseases or parasites found in or on pronghorn. Of the 11 Sonoran pronghorn carcasses collected to date, 2 were collected for the type specimen, 4 were poached, 1 drowned, 1 was road-killed, 1 was killed by coyotes, and 2 died of unknown causes.

Two collared Sonoran pronghorn have died during the study. Buck #149.100 was located on July 13, 1984 on OPNM at the southern end of the Growler Mountains. The skeleton was disarticulated and spread out over a 10 square meter area in a creosote/mixed cacti habitat, with a wash running through the area. All of the skeleton was recovered except one forelimb, the scapulas and ribs. Some skin and hair were left on the skull and limbs; coyotes and vultures had scavenged the carcass, which was evident by the scats found around the skeleton. Cause of death is unknown and the skeleton is being prepared for deposition at the U.S. National Museum.

Doe #149.250 was relocated in the Growler Mountains foothills during a telemetry flight on March 2, 1985, with a mortality signal. Approximately 1 km away from the point of aerial relocation, a normal pulse rate was received. Once in the area of the signal, a visual observation was made of #149.250's doe fawn in the wash at the base of the foothill. While observing the fawn, the collared pronghorn's signal returned to one beep every four seconds. Upon locating the carcass, fresh coyote marks were found on the carcass. The movements of the predator had reactivated the normal pulse rate and it had returned to the mortality mode while relocation was being made. The carcass was found under a paloverde tree at the top of the hill, and there was evidence of a chase and kill. The carcass was intact and rigor mortis had not yet set in; she had been dead only a few hours. Her left flank was missing, as were all organs except the rumen, lungs, heart, thyroid, and a small section of liver. There were hold marks at the base of her neck (none punctured the skin). Necropsy revealed the wounds and mode of consumption were typical of a coyote kill. Analysis of the organs proved unremarkable. The carcass is being prepared for deposition at the U.S. National Museum.

Cause of fawn mortality is unknown at this time; predation by coyotes is strongly suspected.

I. Behavior

The Sonoran pronghorn is morning and evening active on a seasonal basis. The greatest amount of activity occurs in the morning when a great amount of time is spent browsing; just prior to sunrise is when they possibly water. For the remainder of the day, they walk through the flats or bajadas in a loose association within 30 m of each other, browsing on forbs and cacti. Around midday they bed down in response to

heat or wind. On the flats, they bed around the creosote in a loose formation and on the bajadas, low hills or along washes, group under a mesquite or paloverde tree. During long-range movements, they tend to walk single file. When disturbed, they bunch up together to observe and then flee single file (usually with bucks at the front and end of the line) through the flats, stopping every few hundred meters to observe the cause of their disturbance over the tops of the creosote bushes. Late afternoon/early evening is again a time of walking and browsing. They have been observed moving until midnight or 1 a.m., when they bed for the night.

During the first few months of observation, the pronghorn reacted to the observer by fleeing or remaining in the general area but on the defensive (i.e. hair pile erected, normal browsing behavior disrupted, herd gathered together watching the observer). Once habituated to the observer, they remained relatively undisturbed.

During aerial flights, a variety of responses to the airplane are observed. The majority of the animals would stand and stare at the plane then run away at top speed. Others would alternately stand and stare and then mill about restlessly. The two bucks located on the military range almost always stand and stare. On a few relocations, observation was made far enough away so as not to disturb the pronghorn; they continued browsing in a loose herd formation.

Courtship was observed in late March 1984, and signs of male rut were seen from early July until late August. An adult buck was observed missing his left horn sheath in March 1985.

Doe/fawn socialization observations have been limited to a few nursing and grooming episodes. Fawns were usually seen walking behind the doe as she browsed, with the fawn(s) observed nosing the ground or investigating bushes and rocks. Nursing periods were brief; when the doe stopped walking, the fawn walked under her and nursed until the mother moved on. Grooming consisted of a few licks to the fawn by the doe. When fleeing, the fawns ran close behind the doe. Aerial identification of the mother/infant groups is fairly easy for the first six months; the fawns keep in close association to the doe during the flee.

J. Habitat

1. Vegetation Use:

During aerial relocation, vegetation types within the Sonoran Desertscrub and Arizona Upland Series (as described by Brown 1982) were determined for each location. Percentage of habitat use was determined from these relocations. Analysis of vegetation transects conducted at these sites will provide exact species composition and density.

Collared pronghorn were found in the creosote/bursage association 68% (n=268) of the time. This association is utilized for travel corridors, escape routes, and daily ranging year-round. The creosote/ocotillo association and paloverde/ironwood association rank next in use (28%); late winter through summer seasons show a higher use of this habitat type. Does prefer these associations for fawning, and remain in this habitat with the fawns during the spring and early summer. Two collared bucks have occasionally been found in creosote/saguaro association and paloverde/ocotillo association on low hills and a pronghorn sheath was found on top of the Growler Mountains on a creosote/mixed cacti mesa.

Washes and paloverde/mesquite stands are used throughout the year (16% of the time), but mainly during the summer. Pronghorns have been relocated bedded under paloverde or mesquite trees along the edge of the wash during midmorning flights or running towards the edge of the wash for cover from the airplane.

2. Geographical Use:

The broad valleys between the mountains are used throughout the year by the pronghorn. From late winter through the summer, they are located closer to the mountains in the bajadas rather than out on the open flats.

The Pinta Sands area has long been assumed to be a prime location for pronghorn (Carr 1971, 1972). Large numbers were observed in the region during studies by the AGFD in the late 1960s yet, since the late 1970s (when refuge personnel began frequent trips through the area), only five to ten animals were seen at a time. The area is without a permanent water source and, during the extremely dry early 1970s, a movement out of the area to areas with water is believed to have occurred. The sands area in northern San Cristobal Valley still support a herd of five to seven animals during the winter months, and one collared doe frequents the lower end of the Mohawk sand dunes.

The playas are used by the pronghorn during late summer and early fall, when forbs are abundant on the broad flat sand beds. One herd used the Dos Playas as an escape route from the airplane on several occasions.

3. Rainfall Patterns:

Rainfall was calculated for the four vegetative areas from July 1984 until March 1985 (Table 6). The longest monsoon season to date was recorded during the summer in 1984. As expected, half of the yearly precipitation fell from July to September. The Growler Valley received the most precipitation (average 72.9 mm), and the largest number of pronghorn are found in this area. Organ Pipe National Monument and the Mohawk Valley received slightly less and the military range

Table 6. Average seasonal rainfall on Sonoran pronghorn study area, July 1984 to February 1985.

Vegetation Transect Region	July-Sept	Oct-Nov	Dec-Feb
1	64.3	23.9	16.0
2	61.7	18.5	23.9
3	48.3	18.5	20.1
4	72.9	11.6	15.5

Transect Region 1 - Mohawk Valley, middle San Cristobal Valley, Tule Desert

Transect Region 2 - OPNM, lower Growler Valley

Transect Region 3 - Gunnery Range, Childs Valley

Transect Region 4 - Growler Valley, Daniels Arroyo

received approximately one-third less than Growler Valley. The rest of the year shows less than 25 mm during each of the remaining seasons, with Growler Valley receiving the least amount of rainfall. During these seasons, a movement to the north and west is found.

K. Food and Water Habits:

1. Food:

Seasonal vegetative growth occurs following the summer and winter rains and, as a result, pronghorn are opportunistic foragers, as determined by fecal analysis. Forbs occur in large numbers during the spring and fall and are an important food species during those seasons (AGFD 1981). Shrubs and annuals are selected for during the winter, and cacti are selected year-round. Fecal analysis was conducted from 1974 until 1977 by the AGFD; results showed 69% forbs, 22% shrubs, 7% cacti and .4% grasses. These results showed food habits similar to other southern pronghorn. Ranchers in the OPNM region observed the pronghorn feeding on cholla fruit, and the AGFD observed pronghorn feeding on brittlebush, bladderstem, paloverde, and plaintain in the spring (Carr 1970). Monson (1968) stated that the pronghorn fed on dried and withered remains of annual and perennial plants. Cholla fruit has been observed as a favored food; it has a high water content and can be found throughout most of the year.

Perennial grasses and forbs were abundant during the summer and fall of 1984 as a result of the long monsoon season. The pronghorn were observed browsing on forbs, shrubs and cacti; forbs and chain cholla fruit were browsed on during the summer and fall; and brittlebush, chain fruit cholla and ocotillo leaves were browsed on the remainder of the year. On several occasions, forbs were found uprooted and browsed on in areas where pronghorn had been relocated. Fecal samples have been collected and will be analyzed later in the study.

2. Water:

In 1968, Monson stated that there is "no hard evidence that they (Sonoran pronghorn) ever drink water even though it may be available," and that there is "no point in developing water specifically for these animals." He hypothesized that, since these animals were found where there is no water, they must get sufficient amounts of moisture through succulent plants, and have physical and physiological adaptions that conserve water. In Sonora, Mexico, these pronghorn are found in areas without any water sources and apparently do not travel the long distances required to reach water. Yet studies conducted on pronghorn in the desert plains of the western U.S. have shown that they do need water, particularly in the summer, but are opportunistic in drinking (Carr 1973). Beale (1970) found that there was an increase in water consumption by

A. a. americana in Utah when water content of succelents was less than 75%. When the vegetation was dry (water content less than 39%), up to three quarts of water per day was consumed by the pronghorn. A July 1967 census in Red Desert, Wyoming, found 95% of the pronghorn were within 5 km of open water (Sundstrom 1968).

The collared Sonoran pronghorn are found within 8 to 11 km of permanent (wells with open guzzlers or troughs) or semipermanent (Charcos and catchments) water sources (except during long-range movements). Tracks have been found around tanks and troughs during this study and during the AGFD study from 1968-1974. The Cameron Charco herd has been found at the Adobe Windmill trough twice, and are frequently relocated only 100 m away from the trough. Summer movements place all the collared pronghorn within 5 km of a federally maintained water source. During the late summer rains, the pronghorn are not found as frequently near water; seasonal potholes of water may account for the less frequent use of popular watering holes. Tracks have been observed leading up to and away from potholes in the creosote flats and roadways after summer storms. The pronghorn usually water around sunrise and, during the winter, the Cameron herd was found at the Windmill trough during the day.

VI. ASSESSMENTS AND RECOMMENDATIONS

A. General Assessment

1. Population:

The Sonoran pronghorn antelope is considered a separate subspecies based on geographical, morphological and behavioral differences. Six skulls (two does and four buck) have been examined and measured. Goldman (1945) and Paradiso and Nowak (1971) conclude that the measurements and cranial differences warrant a subspecies classification. The Arizona Game and Fish Department (1981) concluded that the measurements fall within the range of extremes for the other three southern subspecies of pronghorn and that, until more skulls could be studied, a subspecies classification was not warranted.

Although numbers in the thousands were once observed, the U.S. population has remained at approximately 100 pronghorn, and the Mexican population has dropped from 500-600 pronghorn to 200-300 pronghorn for the last 75 years. There are no apparent large-scale population movements across the international boundary. The reason for the decline in numbers is a degradation of habitat due to overgrazing and drying of the Gila and Sonoyta Rivers, and the past practice of poaching (Carr 1972). In 1967, the Sonoran pronghorn was placed on the USFWS Threatened and Endangered Species List.

The pronghorn are found in the broad alluvial valleys on CPNWR, OPNM and LAFBGR in the U.S. The low foothills and bajadas are frequently used during the spring and winter months. They are opportunistic feeders and drinkers; they take advantage of what is available on a seasonal basis.

2. Habitat:

The Sonoran pronghorn range is in the lower southwest portion of Arizona and the northern part of the state of Sonora, Mexico. They use the broad, flat valleys between north/south directional mountain ranges. Prior to the conversion of the area to a refuge, national park and gunnery range from 1939 to 1940, cattle grazing and mining were the primary activities in the region. All cattle were removed by 1978 and mining was completely halted in the 1970s. The habitat is still recovering from the overgrazing.

Ranchers dug wells and erected windmills and troughs. These still remain and the refuge has reopened and developed other wells and tanks since 1978. OPNM has maintained ranching wells within the pronghorn's range, and the AGFD maintains several catchments on the LAFBGR.

Human activity is minimal in this region and confined to administrative roads on OPNM and CPNWR. The military conducts air-to-air and air-to-ground ordinance delivery, but impact is minimal and confined to six ranges.

B. Threats

1. Population:

Humans still pose a threat to the Sonoran pronghorn. Poaching still occurs in Mexico but is minimal in the U.S. due to different law enforcement practices. Human activity on the pronghorn range creates minimal disturbances to the herds and does not pose any long-term threat since activity is greatly restricted by the land managing agencies.

Coyotes, bobcats and possibly mountain lions are the only known pronghorn predators in the region. Coyote predation has been documented during the study, and several collared pronghorn have had a coyote associated within 1.7 km of their herds. During the 1960s, 1080 was used as a predator control, with no apparent benefit to the pronghorn (AGFD 1981).

2. Habitat:

The major threat to the habitat (cattle) was removed in 1978. The combined effect of cattle grazing and drying of the rivers in the region resulted in a degradation of forage quality and abundance. Shortage of permanent water sources continues today, but water development is relieving some of the

pressure to the wildlife.

Another threat to the habitat is off-road travel. Off-road travel is prohibited, yet does occur on the gunnery range by ordinance personnel as well as by trespass civilians and occurs infrequently on CPNWR and OPNM.

C. Existing Management

1. Population:

The Sonoran pronghorn is listed as endangered and is federally protected. Hunting of the subspecies was prohibited in 1922 in the U.S. Management is mainly custodial and conducted by refuge personnel and park service employees. Records are kept on all observations and both agencies promote public awareness of the protected status of the pronghorn and its habitat.

2. Habitat:

The range of the Sonoran pronghorn is managed by three agencies (USFWS, USPS and USAF) and a dozen other agencies have input in the various studies, inventories and land use of the region. All three agencies restrict human activity in the area; CPNWR and OPNM prohibit off-road driving and large portions of their land holdings are inaccessible to most people. LAFB limits public use on the gunnery range to a few hunting days (for other game species) in the fall. Travel in all three areas is restricted to administrative roads. This keeps disturbance to the habitat at a minimum.

Water hole development and maintenance is performed by OPNM and CPNWR, and by the AGFD on the military range. Water is hauled to the catchments; windmills and tanks are periodically checked to maintain the water level at half full or more.

Since the two rivers within the pronghorn's range have dried during the last 100 years, it is not known what the present-day optimum for vegetation is in the region. Both CPNWR and OPNM are documenting the recovery of the habitat from overgrazing. CPNWR is currently conducting a series of vegetation transects in the Cameron Charco area, once a heavily grazed section of the refuge. This documentation of recovery will provide a baseline for determining forage quality and availability for the pronghorn.

D. Proposed Management

1. Population:

In 1982, a recovery plan was drafted by the U.S. Fish and Wildlife Service for protection of the pronghorn and habitat. It proposed a plan for maintaining existing population numbers

and distribution, and increasing the U.S. population to 300 animals (averaged over a five-year period) or numbers feasible for the habitat. Once this number is met and major threats are reduced, the subspecies would be considered for delisting. Several problems would be encountered with this plan. Mexican recovery objectives and methods would have to be different due to the exploitation of pronghorn and law enforcement practices. There is also no clear means of increasing the population, except by habitat protection. Congress is currently considering a wilderness designation for a large portion of the CPNWR. This would restrict vehicular travel through portions of the refuge. However, this would pose a problem in maintaining wells and catchments within the pronghorn's range.

Several water sources are currently being considered for development or redevelopment on the refuge. These wells are within known home ranges of collared pronghorn. A new catchment is also being considered in a portion of the military range where collared pronghorn are found during the fall and winter.

2. Conservation Recommendations:

Habitat protection and improvement are critical in maintaining the Sonoran pronghorn's current distribution. There are several projects that need to be employed to maximize the recovery potential for this subspecies. Listed below are those projects that are most important.

a. Continue to remove any trespass domestic livestock that are found on any of the area used by Sonoran pronghorn. This is being done not only to enhance the vegetative recovery of the range but to reduce the possibility of introducing domestic livestock disease that could lead to an epizootic.

b. Continue to enhance or develop new water sources that are available to pronghorn use. This effort should place emphasis on areas where free water is unavailable. One of the first areas that should be addressed is in the area east of the Aguila Mountains.

c. Until the carcasses of the three pronghorn collected on this study have been reviewed for taxonomic assignment, the current legal status of the Sonoran pronghorn should be maintained.

d. In view of the insight gained into the current status of the Sonoran pronghorn during this study, collared pronghorn should be fitted with new telemetry equipment and the study

should continue to be funded until September 30, 1987. This would allow refinement of many of the data collected to date.

e. Any major new impacts into areas utilized by Sonoran pronghorn should not be planned within 10 km of a permanent water source. Examples of this would be an impact or target area. Impacts such as new roads should be routed to avoid permanent water sources.

f. Any changes in status of the range (i.e. wilderness status) should recognize that water developments are apparently important to Sonoran pronghorn and maintenance should be a permitted activity.

Literature Cited

Asdell, S.A. 1946. Patterns of Mammalian Reproduction. Comstock Publishing Co. Ithaca, New York.

Arizona Game and Fish Commission. 1982. Threatened native wildlife in Arizona. Ariz. Game and Fish Dept. Publ.

Arizona Game and Fish Department. 1981. The Sonoran Pronghorn. Special Report #10. Project W-53-R. Work Plan 1, Job 1. Ariz. Game and Fish Dept.

Beale, D.M. and A.D. Smith. 1970. Forage Use, Water Consumption and Productivity of Pronghorn Antelope in Western Utah. J. Wildl. Manage. 34(3):570-582.

Brown, David E. (editor). 1982. Biotic Communities of the American Southwest United States and Mexico. Desert Plants 4 (numbers 1-4).

Carr, John N. 1969. Completion Report - Endangered Species Investigation, Sonoran Pronghorn pp1-5. Ariz. Game and Fish Dept.

_____. 1970. Progress Report - Endangered Species Investigation, Sonoran Pronghorn pp203-207. Ariz. Game and Fish Dept.

_____. 1971. Progress Report - Endangered Species Investigation, Sonoran Pronghorn pp247-262. Ariz. Game and Fish Dept.

_____. 1972. Progress Report - Endangered Species Investigation, Sonoran Pronghorn pp1-9. Ariz. Game and Fish Dept.

_____. 1973. Performance Report - Endangered Species Investigation, Sonoran Pronghorn pp1-11. Ariz. Game and Fish Dept.

Halloran, A.F. 1957. A note on Sonoran pronghorn. Jour. Mammal Vol. 38, No. 3, pp423.

Goldman, E.A. 1945. A New Pronghorn from Sonora. Proc. Biol. Soc. Washington. 58:3-4.

Kitchen, David W. 1974. Social Behavior and Ecology of the pronghorn. Wildlife Monogr. 38:1-96.

_____ and Bart W. O'Gara. 1982. Pronghorn (Antilocapra americana) Wild Mammals of North America. Johns Hopkins University Press.

LeCount, A., and W.K. Carrell. 1979. Removable rotary antenna handle for aerial radio tracking. Fed. Aid Wildl. Res. Project W-78-R-20 Research Division Ariz. Game and Fish Dept. Memo.

Lucas, H.A. and C.A.F. Seber. 1977. Estimating coverage and particle density using the line intercept method. Biometrika 64:618-622.

MacArthur, R.H. and J.W. MacArthur. 1961. Vegetation analysis technique/Board Technique on bird species diversity. Ecol. 42:594-598.

Monson, Gale. 1968. The Desert Pronghorn. Desert Bighorn Council 1968 Transactions. pp63-69.

National Park Service. 1977. Natural and Cultural Resources Management Plan and Environmental Assessment. Organ Pipe Natl. Monu., Arizona. pp29-47.

_____. No date. Statement for Management. Organ Pipe Natl. Monu., Arizona.

_____ and UofA. 1981. Vegetation of Organ Pipe Cactus National Monument. Technical Report No. 8. Office of Arid Lands Studies. UofA, Tucson, Arizona.

Nations, Dale and E. Stump. 1981. Geology of Arizona. Kendall/Hunt Publishing Co.

Natural Resource Planning Team, UofA. 1984. Natural Resource Management Planning for Luke Air Force Range, Phase 1. College of Agriculture, School of Renewable Natural Resources, UofA. Tucson, Arizona.

Nelson, E.W. 1925. Status of the Pronghorned Antelope, 1922-1924. U.S. Dept. of Agric. Bull. 1346:64.

Nichol, A.A. 1941. Game Reconnaissance of Southwestern Arizona, south of the Gila River. Unpubl., Ariz. Game and Fish Dept.

Paradiso, J.L. and R.M. Nowak. 1971. Taxonomic status of the Sonoran Pronghorn. Jour. Mammal. 52(4):855-858.

Phelps, John S. 1974. Performance Report - Endangered Species Investigation, Sonoran Pronghorn. Ariz. Game and Fish Dept.

Sellers, W.D. and R.H. Hill. 1974. Arizona Climate 1931-1972. UofA Press, Tucson, Arizona. Second Edition.

Shreve, F. and I.L. Wiggins. 1964. Vegetation and Flora of the Sonoran Desert. Vols. I and II. Stanford University Press, Stanford, CA.

Sundstrom, C. 1968. Water Consumption by Pronghorn Antelope and Distribution Related to Water in Wyoming's Red Desert. Proc. Antelope States Workshop 3:39-46.

U.S. Fish and Wildlife Service. 1982. Sonoran Pronghorn Recovery Plan.

_____. 1983. Endangered and Threatened Wildlife and Plants 50 CFR 17.11 and 17.12.

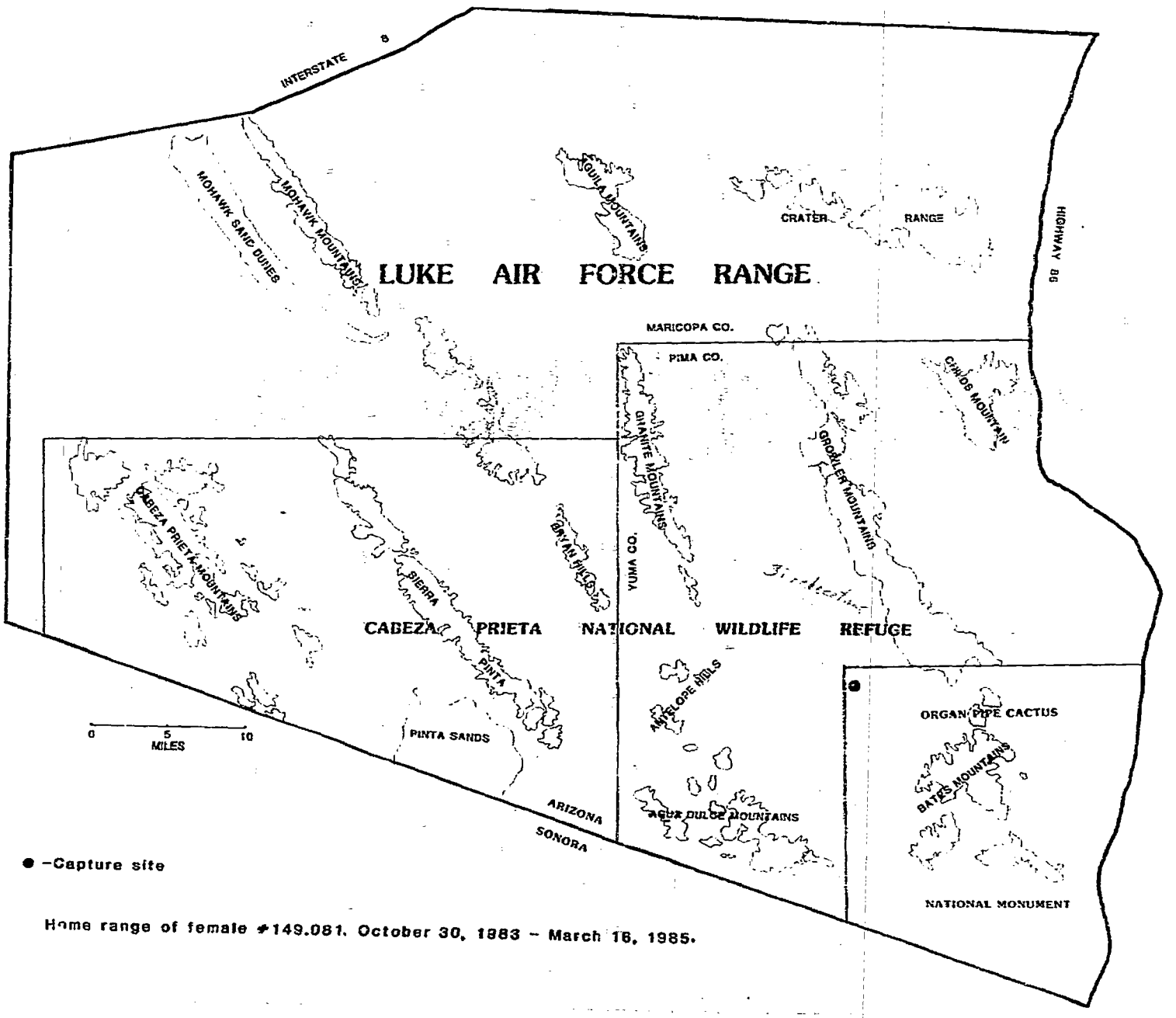
_____. 1984. Code of Federal Regulations. Title 50, Chapter 1, Parts 1 to 199. Office of Federal Register, National Archives and Records Service.

Villa R., B. 1958. Partial account of Prof. Bernardo Villa R. concerning the study of bighorn sheep and antelope in northern Mexico. Instituto de Biologia, Mexico, D.F. Unpubl.

Wallace, A. (editor). 1965. Pumpelly's Arizona. An excerpt from "Across America and Asia" by Raphael Pumpelly. The Palo Verde Press, Tucson, Arizona.

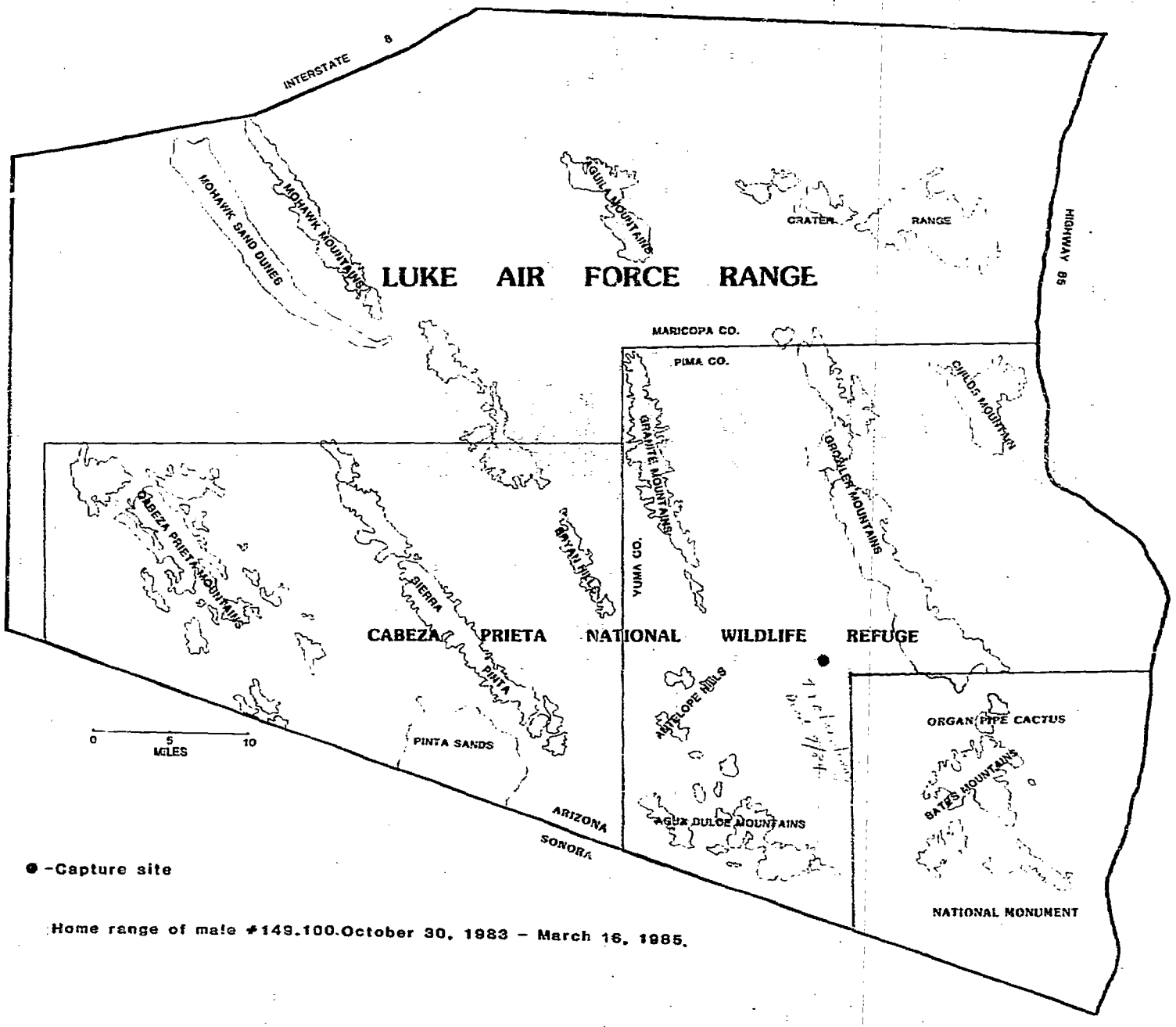
APPENDIX A

Home Ranges of Collared Sonoran Pronghorn Antelope, October 1983 - March 1985



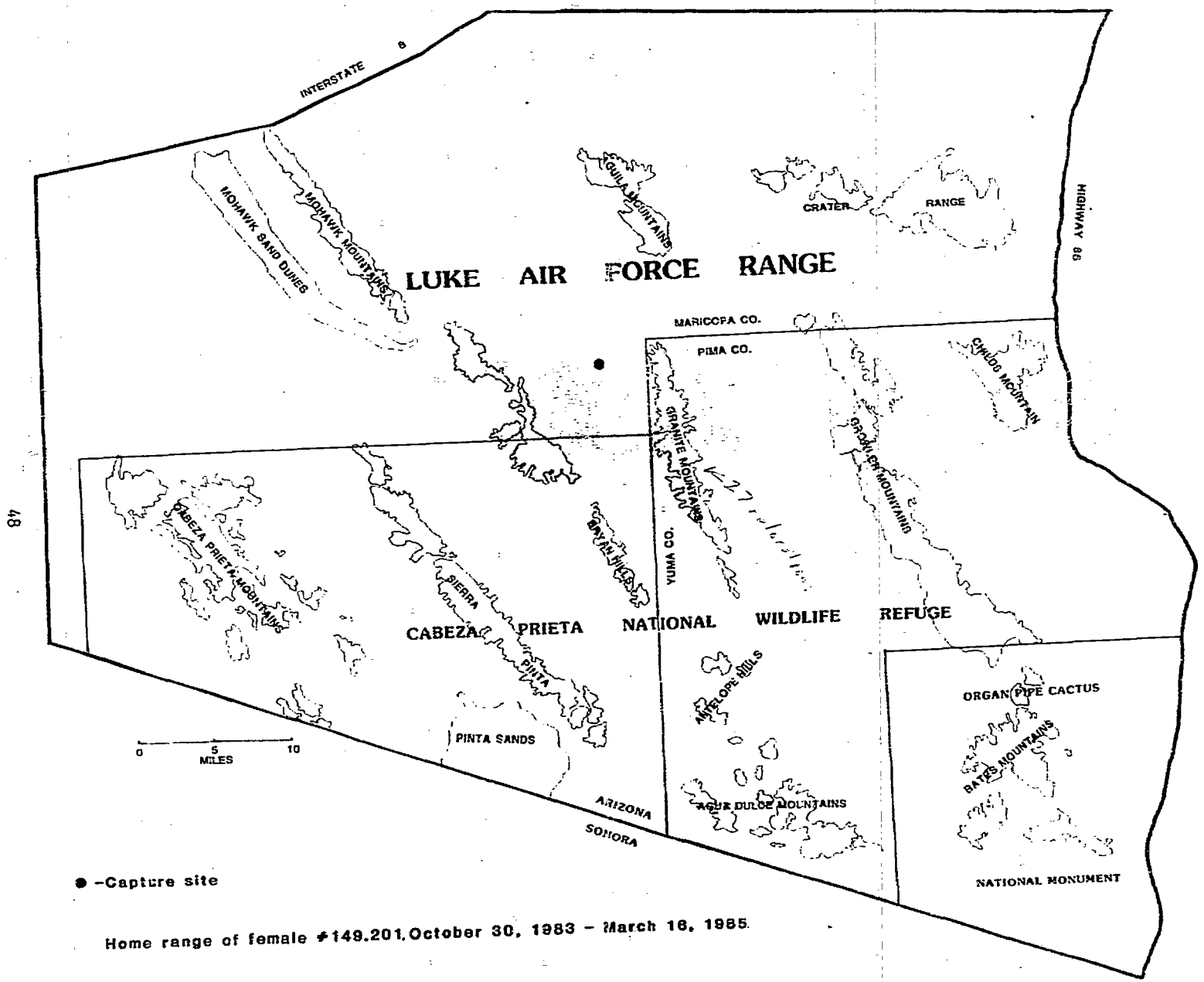
● –Capture site

Home range of female #149.081, October 30, 1983 – March 16, 1985.



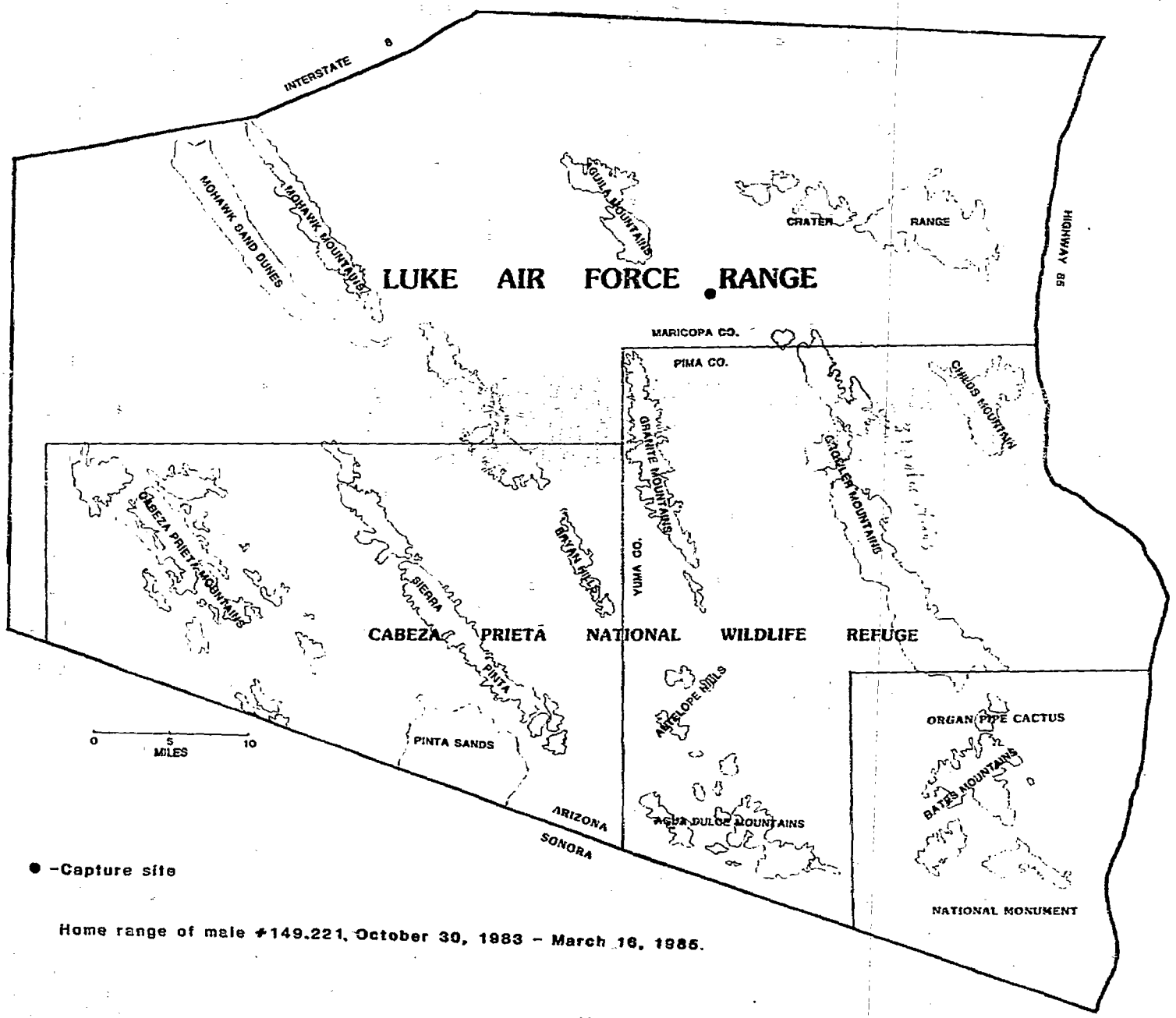
● -Capture site

Home range of male #149.100.October 30, 1983 – March 16, 1985.



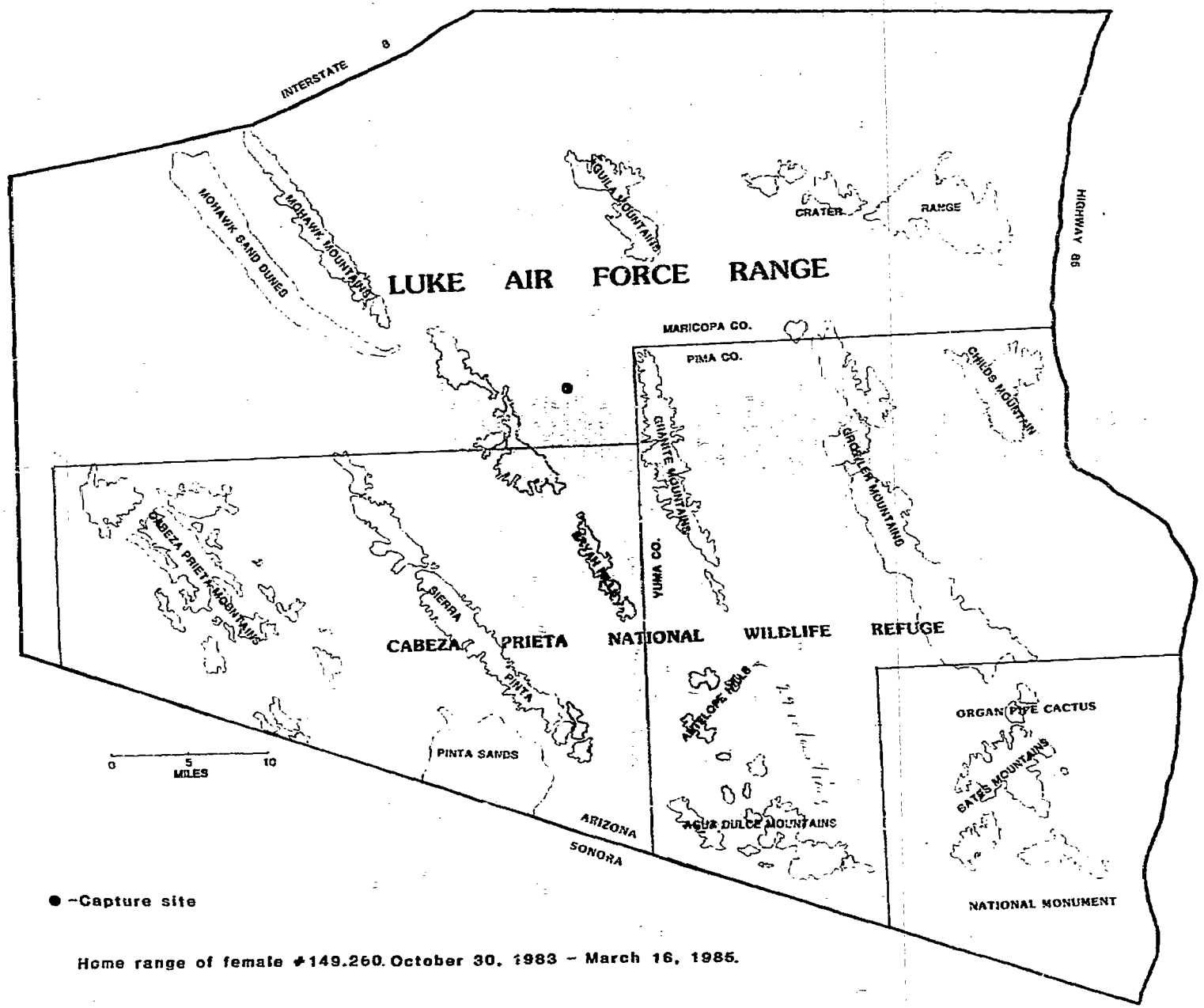
● –Capture site

Home range of female #149.201. October 30, 1983 – March 16, 1985.



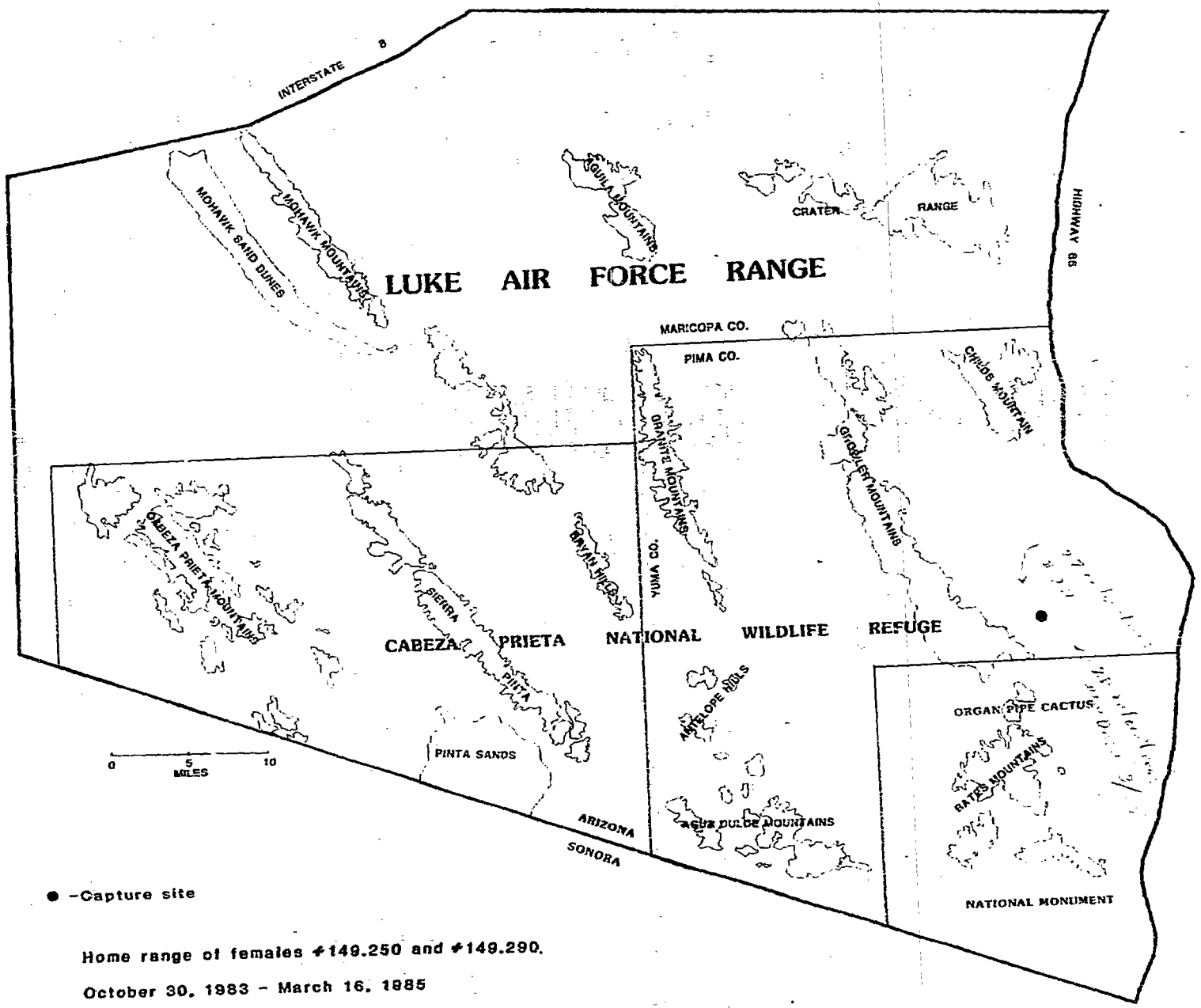
● -Capture site

Home range of male #149.221, October 30, 1983 - March 16, 1985.



● –Capture site

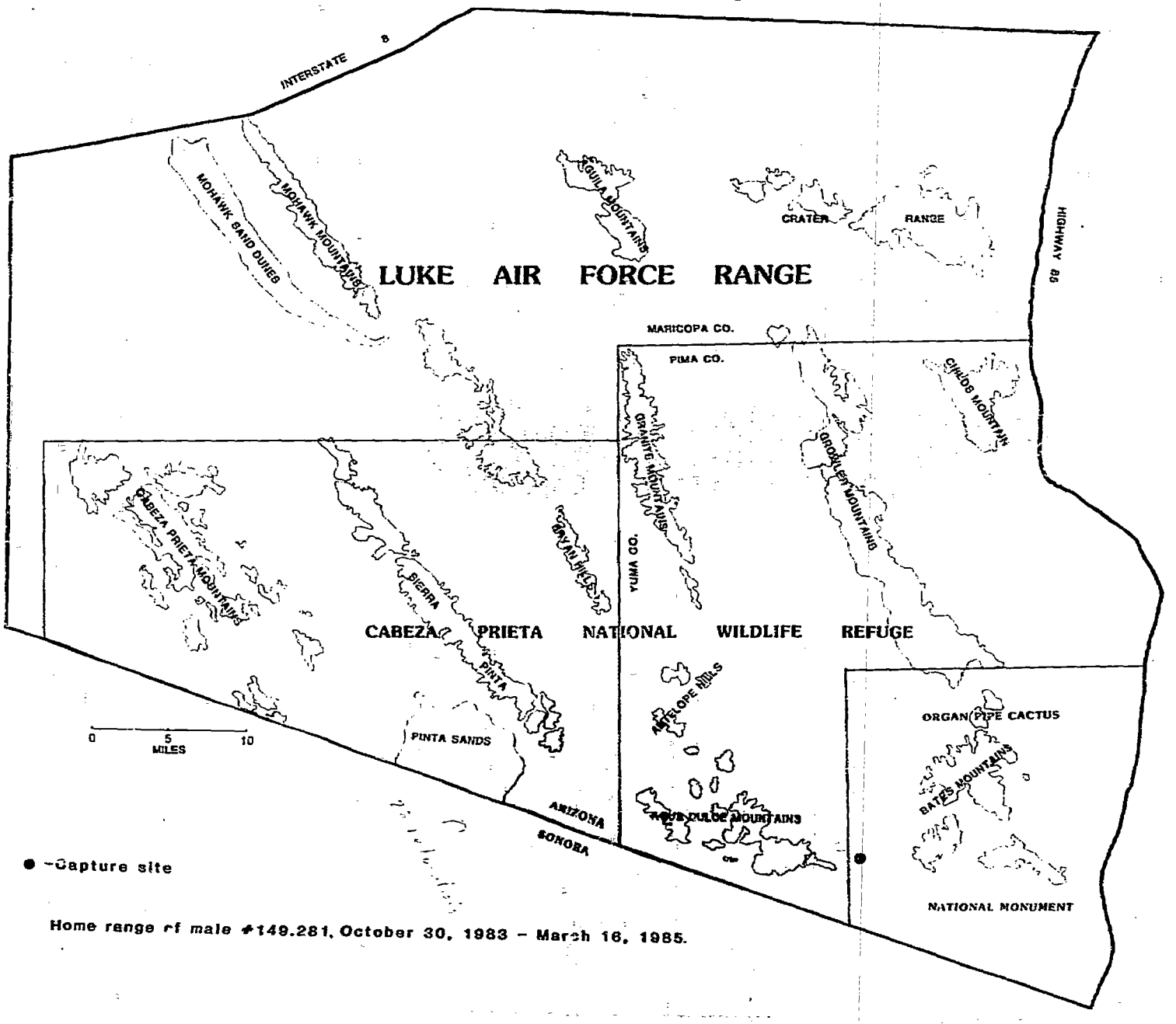
Home range of female #149.260. October 30, 1983 – March 16, 1985.



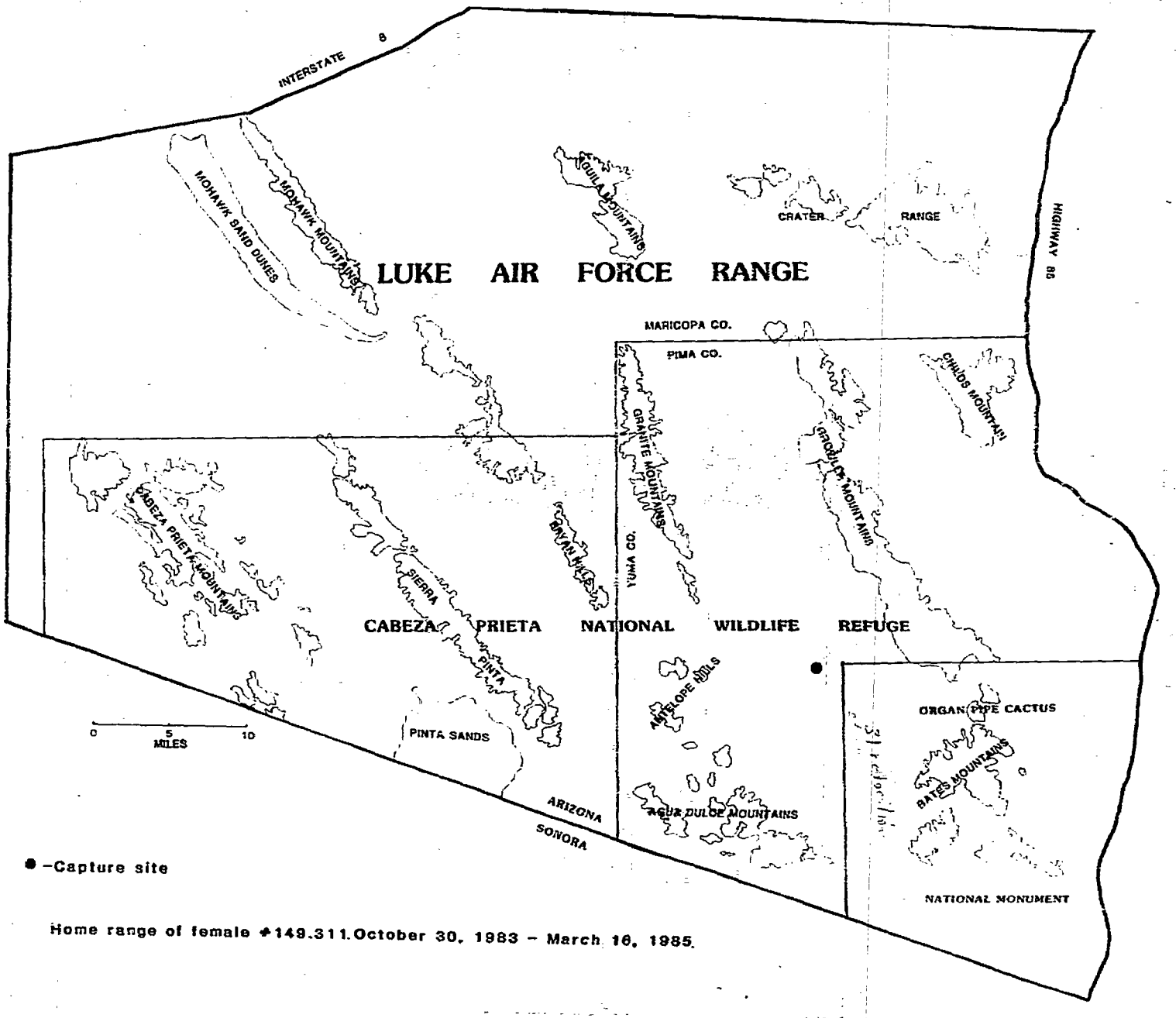
● –Capture site

Home range of females #149.250 and #149.290.

October 30, 1983 – March 16, 1985

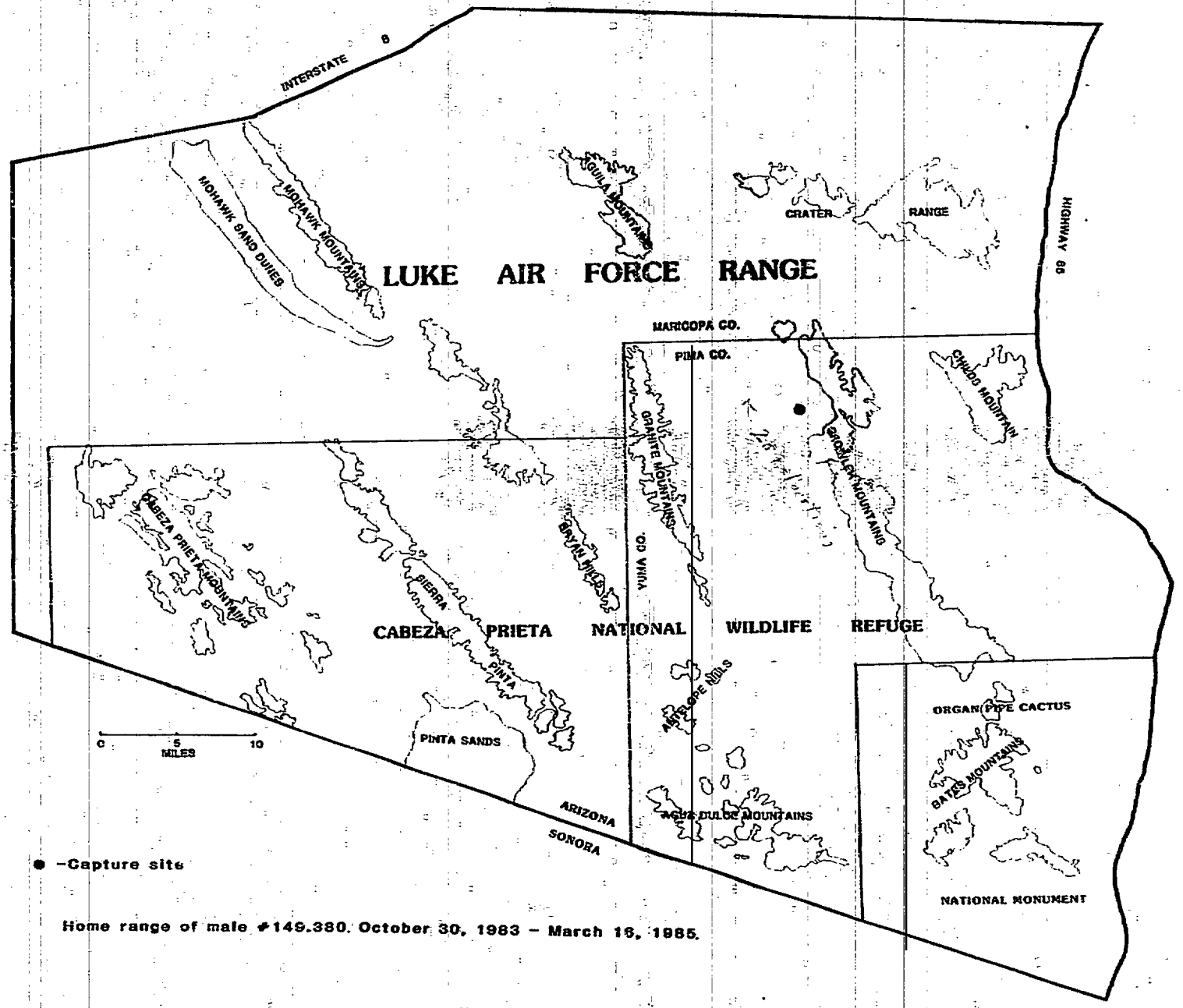


Home range of male #149.281, October 30, 1983 – March 16, 1985.



● –Capture site

Home range of female #149.311.October 30, 1983 – March 16, 1985.

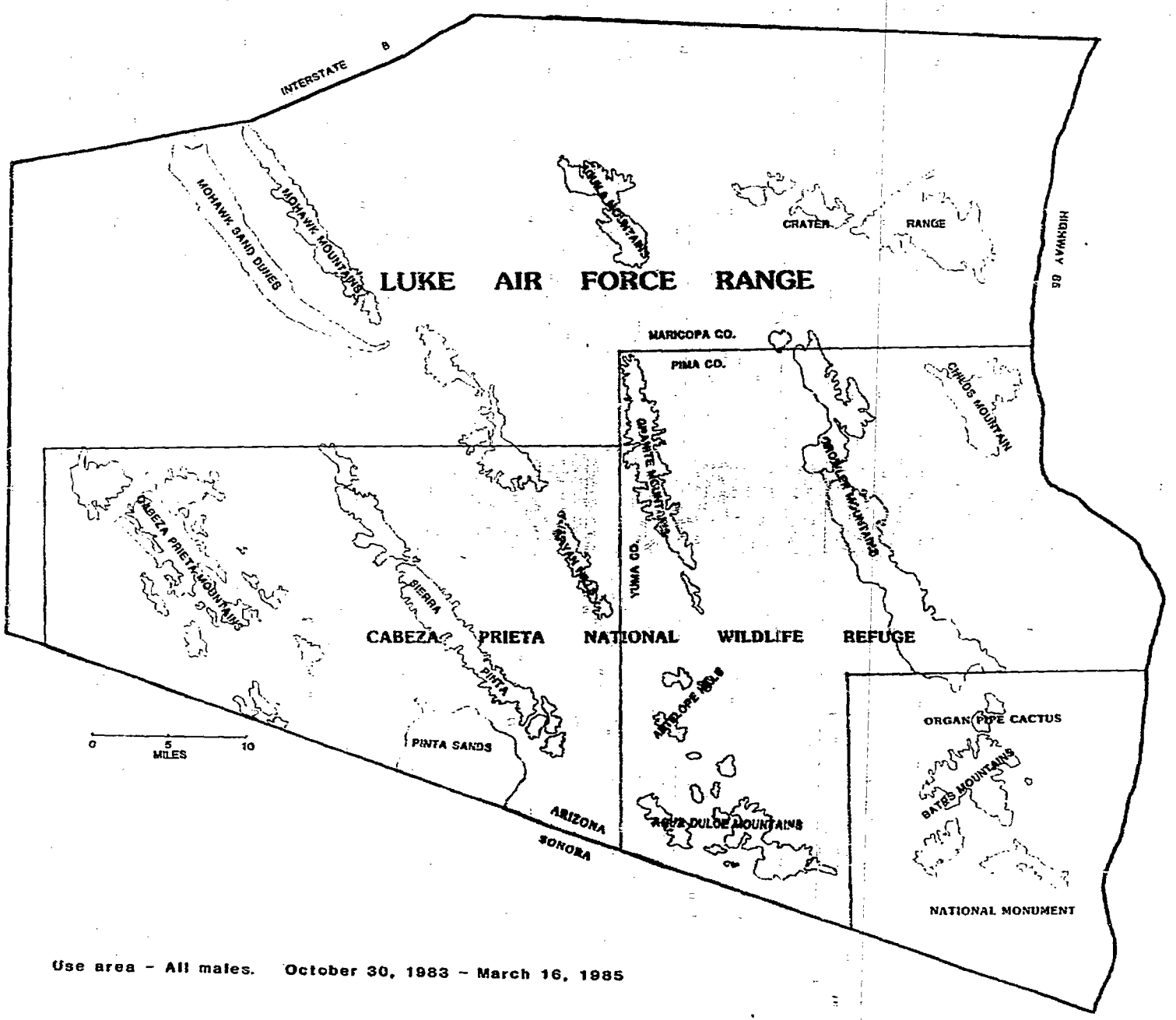


● –Capture site

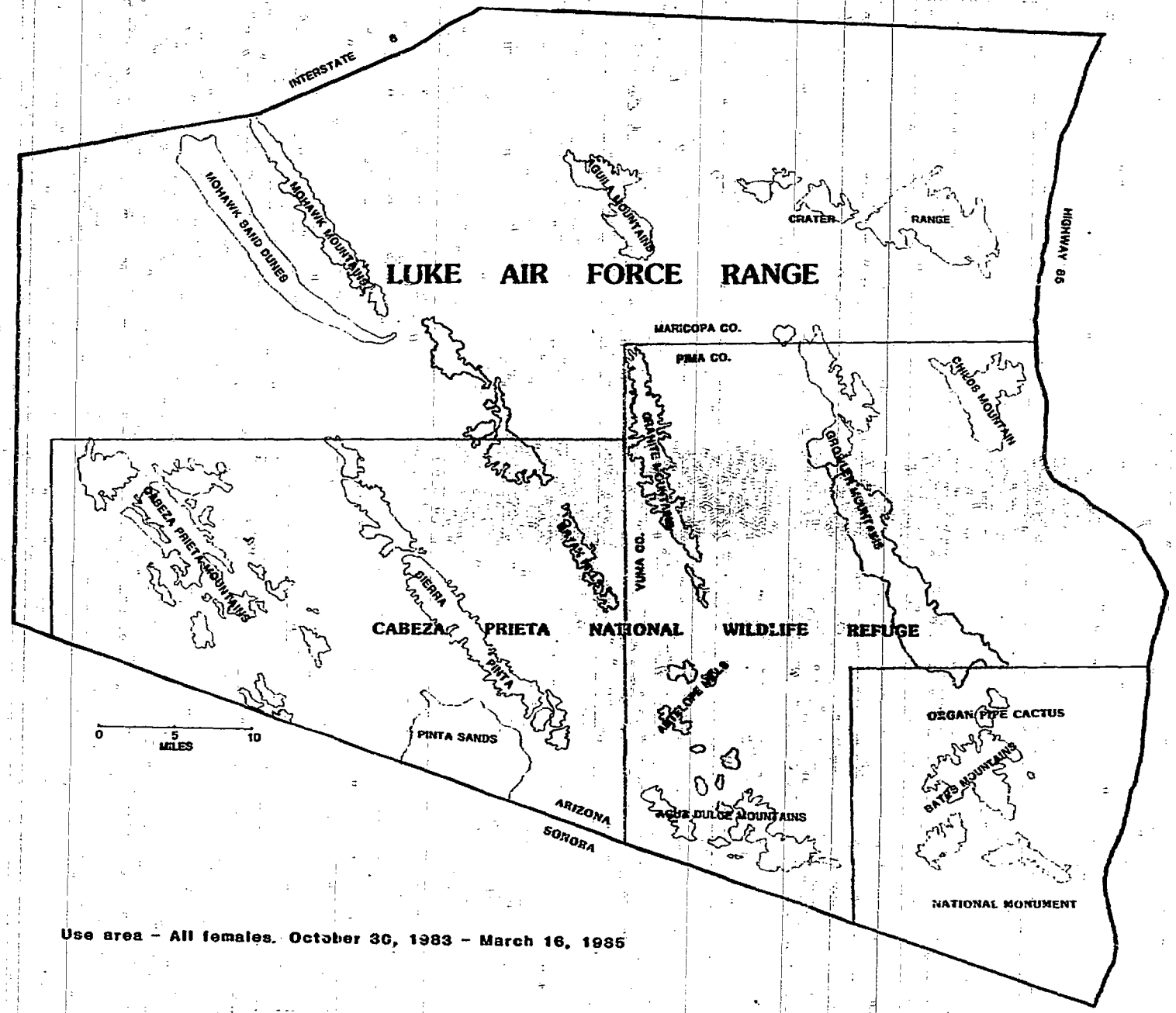
Home range of male #149.380. October 30, 1983 – March 16, 1985.

APPENDIX B

Use Area of Collared Female
Sonoran Pronghorn Antelope,
October 1983 - March 1985



Use area - All males. October 30, 1983 - March 16, 1985



Use area - All females. October 30, 1983 - March 16, 1985